ICDBSE

A·P·U
ASIA PACIFIC UNIVERSITY
OF TECHNOLOGY & INNOVATION

46th STOU Anniversary

E-PROCEEDINGS

The 2nd International Conference
of Digital Business, Society & Economy

ICDBSE 2024

Innovation and Technology Towards Sustainability and Lifelong Learning

13-14 November 2024

Sukhothai Thammathirat Open University
Nonthaburi, Thailand

Partners

ASIAN ASSOCIATION OF OPEN UNIVERSITIES

INTERNATIONAL COUNCIL FOR OPEN AND DISTANCE EDUCATION

Southeast Asian Ministers of Education Organization

CHITKARA UNIVERSITY

OUM OPEN UNIVERSITY MALAYSIA

University of the Philippines OPEN UNIVERSITY

UNIVERSITAS TERBUKA

SUKHOTHAI THAMMATHIRAT OPEN UNIVERSITY

THE 2ND INTERNATIONAL CONFERENCE OF DIGITAL BUSINESS, SOCIETY & ECONOMY PROCEEDINGS BOOK

NONTHABURI, THAILAND

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any from or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.

The 2nd International Conference of Digital Business, Society, and Economy Proceedings Book

Copyright © 2025

Published by **Sukhothai Thammathirat Open University**

1st Edition

National Library of Thailand Cataloging in Publication Data

The 2nd international conference of digital business, society, and economy proceedings book.--
Nonthaburi : Sukhothai Thammathirat Open University, 2025.

630 p.

1. Electronic commerce. 2. Economics. 3. Continuing education. 4. Technological innovations.
I. Title.

658.872
ISBN (e-book): 978-616-94562-5-4

FOREWORD

We are pleased to present the Proceedings of the 2nd International Conference of Business, Society & Economy (ICBSE2024). This volume encapsulates the rich intellectual discourse and innovative ideas that were exchanged during the conference, held on 13-14 November 2024 at Sukhothai Thammathirat Open University, Thailand.

The conference theme, "Innovation and Technology Towards Sustainability and Lifelong Learning," proved to be a catalyst for stimulating discussions and insightful presentations. The keynote speeches, panel discussions, and parallel sessions explored a wide range of topics, including Innovative Technology for Lifelong Learning, Digital Business Transformation, and Quality Framework for Lifelong Learning.

These proceedings offer a valuable collection of research papers, case studies, and practical insights from scholars in the field. The contributions from esteemed academics and industry practitioners highlight the latest advancements and future trends in business, society, and economy.

We extend our sincere gratitude to all the authors, reviewers, session chairs, and participants who contributed to the success of the conference and the production of this e-Proceedings. We hope that this volume will serve as a valuable resource for researchers, policymakers, and practitioners alike, inspiring further innovation and collaboration.

We look forward to the continued growth and impact of the ICBSE series in the years to come.

The ICDBSE2024 Conference Committee

COMMITTEE MEMBERS

EXECUTIVE COMMITTEE

Chair: Assistant Professor Dr. Phanompatt Smitananda
Vice-Chair: Associate Professor Dr. Gan Chanyawudhiwan
Members: Associate Professor Dr. Thanasak Saijampa
Associate Professor Dr. Narathip Sriram
Associate Professor Dr. Kittipong Keatwatcharachai
Assistant Professor Dr. Akadet Manoleehagul

ORGANIZING COMMITTEE

Chair: Associate Professor Dr. Gan Chanyawudhiwan
Members: Associate Professor Dr. Chanoknart Boonwatthanakul
Associate Professor Dr. Sungworn Ngudgratoke
Associate Professor Dr. Taweewat Wathanakuljaroen
Associate Professor Krittika Jiwaluk
Assistant Professor Dr. Isares Sunsaneevithayakul
Assistant Professor Dr. Jeeranuch Buddeejeen
Assistant Professor Dr. Padcharee Phasuk
Assistant Professor Dr. Parichat Dittakit
Assistant Professor Dr. Poom Juasiripukdee
Assistant Professor Dr. Seksan Amatmontree
Assistant Professor Dr. Sornchai Sinsuwan
Assistant Professor Witoon Wong-a-mart
Dr. Sarun Nakthanom
Mr. Apiwan Jarernlap
Mr. Kasitat Chantawong
Mr. Yodchai Suksachart
Miss Rapeepan Tanwanchai
Miss Jiraporn Hongsopa
Miss Chidchanok Bangsen
Miss Parichaya Muangmin
Secretary: Mrs. Rattip Phukkeson
Assistant Secretaries: Miss Warakanya Thanarak
Mrs. Alisa Bhesayanavin
Mrs. Satiya Wajakham

ACADEMIC COMMITTEE

Chair:	Associate Professor Dr. Narathip Sriram
Vice-Chair:	Associate Professor Dr. Gan Chanyawudhiwan
Members and Reviewers:	Associate Professor Dr. Jiraporn Sudhankitra
	Associate Professor Dr. Monwipa Wongrujira
	Associate Professor Dr. Namtip Wipawin
	Associate Professor Dr. Sita Yiemkuntitavorn
	Associate Professor Dr. Somporn Puttapithakporn
	Associate Professor Dr. Supawadee Theerathammakorn
	Associate Professor Dr. Wararak Chalermpuntusak
	Associate Professor Dr. Pithak Srisuksai
	Assistant Professor Dr. Abhirat Supthanasup
	Assistant Professor Dr. Chalermpon Jatuporn
	Assistant Professor Dr. Khajitpan M Kritpolviman
	Assistant Professor Maj. Dr. Napaphen Jantacumma
	Assistant Professor Dr. Narubodee Wathanakom
	Assistant Professor Dr. Noppol Akahad
	Assistant Professor Dr. Patthanan Bootchuy
	Assistant Professor Dr. Songlak Sakulwichitsintu
	Assistant Professor Dr. Supanita Sudsaward
	Assistant Professor Dr. Wannaprapha Suksawas
	Assistant Professor Bhawat Chiamjinnawat
	Dr. Supamas Chumkaew
	Dr. Worrawit Nakpan
Secretary:	Mrs. Rattip Phukkeson
Assistant Secretaries:	Mrs. Alisa Bhesayanavin
	Miss Wachiraporn Tharanart

PANEL OF INTERNATIONAL REVIEWERS

ASIA PACIFIC UNIVERSITY OF TECHNOLOGY & INNOVATION

Assoc. Prof. Dr. Senthil Kumar Thiagarajan
Dr. Ahmad Danial Bin Zainudin
Dr. Hafinaz Hasniyanti Hassan
Dr. Muhammad Umar Islam
Dr. Morakinyo Dada
Dr. Nurul Farhaini Razali
Dr. Ooi Bee Wah
Dr. Vikneswaran Manual
Miss Analisa Hamdan

CHITKARA UNIVERSITY
Ms. Namita Sharma
Ms. Ishani Sharma
Ms. Divya Goswami
Ms. Nitika Sharma
Ms. Shefali Sharma
Ms. Rupinder Kaur

HANOI OPEN UNIVERSITY
Associate Professor Dr. Nguyen Mai Huong
Dr. Duong Thang Long
Dr. Nguyen Thi Thu Huong

OPEN UNIVERSITY MALAYSIA
Associate Professor Dr. Zahir Osman
Associate Professor Dr. Nantha Kumar Subramaniam
Dr. Md Rosli Ismail

UNIVERSITAS TERBUKA
Professor Tian Belawati, M.Ed., Ph.D.
Professor Aminudin Zuhairi, Ph.D.
Rahmat Budiman, M.Hum., Ph.D.

UNIVERSITY OF THE PHILIPPINES OPEN UNIVERSITY
Professor Dr. Jean A. Saludadez
Professor Dr. Ricardo Bagarinao

INTERNATIONAL ORGANIZING COMMITTEE

Chair:	Associate Professor Dr. Gan Chanyawudhiwan
Members:	Associate Professor Dr. Taweewat Wathanakuljaroen
	Associate Professor Dr. Sungworn Ngudgratoke
	Associate Professor Dr. Senthil Kumar
	Assistant Professor Dr. Padcharee Phasuk
	Assistant Professor Dr. Poom Juasiripukdee
	Dr. Hafinaz Hasniyanti Hassan
	Dr. Nurul Farhaini Razali
	Ms. Analisa Hamdan
Secretary:	Mrs. Rattip Phukkeson
Assistant Secretaries:	Miss Warakanya Thanarak
	Mrs. Alisa Bhesayanavin

PANEL OF BEST PAPER AWARD COMMITTEE

Emeritus Professor Dr. Xiangyang Zhang
Professor Ts. Dr. Murali Raman
Professor Dr. Jean A. Saludadez
Professor Dr. Songhua Wang
Professor Dr. Xiao Zhang
Associate Professor Dr. Gan Chanyawudhiwan
Associate Professor Dr. Somporn Puttapithakporn
Associate Professor Dr. Wararak Chalermpuntusak
Assistant Professor Dr. Chalermpon Jatuporn
Assistant Professor Dr. Wisanan Ouparamai
Dr. Amit Mittal
Dr. Lidwina Sri Ardiasih

TABLE OF CONTENTS

FOREWORD III

COMMITTEE MEMBERS V

TABLE OF CONTENTS IX

CONFERENCE PROGRAM 1

SPEAKERS, PANELISTS & MODERATORS 3

FULL PAPERS

SUB-THEME 1 DIGITAL BUSINESS & ECONOMY

The Impact of Digital Business Investment on Income, Employment, and Economic Growth in the Thai Economy
Anucha Wittayakorn-Puripunpinyoo 21

The Role of a Technical College in the Thai Digital Economy Development: From Policy to Practices
Anucha Wittayakorn-Puripunpinyoo 32

Ethical Application of AI in Business Research in Higher Education: A Literature Review
Anothai Ngamvichaikit 44

CEO's Financial Background and Enterprise Digital Transformation: Empirical Evidence from Chinese Listed Companies
Changchun Zhu 50

Digital Tooling with Soft Power to Drive the Smart Silver Economy under the Aged Society of Thailand
Kamolrat Intaratat 72

Forecasting OTOP Product Sales Using Time Series Analysis and Machine Learning
Songpol Khuptachit 73

Leveraging Electronic Word-Of-Mouth and Trust to Drive Dietary Supplement Consumption
Paul Kalin 84

Can a Comprehensive Conceptual Framework Unlock Effective Gen-AI Integration in Malaysia, Indonesia, and the Philippines' Education?
Analisa Hamdan 94

Thailand's Economic Structural Transformation: What Happens After the Health Crisis is Over?
Padcharee Phasuk 95

Monopolistic Influence on Policy Performance: A DSGE Approach to Thailand's Technology and Agricultural Sector Economy
Adirek Vajrapatkul 105

Enhancing Business Confidence Index Forecasting Using Artificial Neural Networks and Multiple Regressions: A Case Study of Thailand
Adirek Vajrapatkul 117

Retail Sales Forecasting Using Machine Learning Techniques: A Comparative Analysis of MLR, ANN, AND KNN Models
Adirek Vajrapatkul 132

Testing Cointegration Between Stock Market Returns and Selected Technology Stock Returns with Structural Breaks
Saowakhon Nookhao 154

Forecasting Stock Market: An Application of Arima And Brownian Motion Models
Voranon Khundilokkamol 166

Analyzing Long-Run Relationships Among Leading Stocks Sectors
Jongrak Dangfoo 182

An Individual Consumption Taxation Model in Malaysia
Nurul Farhaini Razali 199

Determining the Challenges Faced by Auditors with Audit Automation
Ibrahim O.A. Eriqat 200

SUB-THEME 2 DIGITAL LEARNING & SOCIETY

Society 5.0 and Digital Transformation in Life Long Learning: A Qualitative Study
P. Sivakumar 213

Society 5.0: Crafting the Future of Public Governance
Prayote Songklin 222

Creating New Strategic Approaches for Virtual Learner-Centered Group Projects with Artificial Intelligence (AI)
Bob Barrett 233

Does Artificial Intelligence-Enabled Transformation Acceptance Matter in Digital Higher Education Institutions?
Zahir Osman 244

Bridging the Digital Divide: Gender and Age Disparities in AI Adoption Within the Framework of Society 5.0
Zahari Hamidon 257

Understanding Household Behavior and Effective Policies for Waste Sorting in Phetchaburi Province,Thailand
Kamonporn Siripanachai 269

The Construction of a Model and Promotion Strategies for Open University Teachers' Digital Competence from An International Perspective
Hou Haibing 287

Exploring Mental Health Issues, Needs, and the Role of Counseling Services for Students and Staff at Open University Malaysia (OUM)
Mohd Azli Jailani 299

Bridging Campus Engagement with Virtual Reality (VR): A Study on Women's Acceptance of VR Campus Tour in An Open University
Myra C. Almodiel 323

Analyzing the Acceptance of Collaborative Learning Tools Among Online Students Using the Technology Acceptance Model
Jia Paladin Billones 332

Analysing Risks in Online and Distance Learning: An Enterprise Risk Management Approach for Open and Distance Learning Institutions
Raziana Che Aziz 346

Enhancing Master Project Completion for Part-Time Science and Technology Master's Students at Open University Malaysia: Integrating Technology and Support Systems
Suhaila Abdul Hamid 347

Exploring the Sense of Presence in A Virtual Reality- Enhanced Campus Tour of an Open University
Anna Ma. Elizabeth Cañas-Llamas 363

AI and OER in China: Transforming the Future of Open Education
Wen Tang 375

Redefining Educational Paradigms: A Case Study of China's Smart Education Platform in the Digital Age
Wen Tang 386

Research on the Practical Path of Digital Business Services for Lifelong Learning for All
Fu Tianbo 397

The Economic Impact of Water Vulnerability to Corporate Sustainability: A Perspective of Corporate Capital Cost
Gao Pengqun 406

Decentralized Web3 Platform Enhanced with AI and IoT for Urban Community Farming: A Strategic Approach to Achieving Society 5.0
Kwan Jun Er 435

Practical Approaches to Prompt Engineering for AI-Driven Image Generation
Zahari Hamidon 451

Legal Perspectives for The Accommodation of a Potential Global Society 5.0: IT, Cyber and Privacy Laws
Ananya Anand 464

Implementing Bubbles of Integrity: SOAP's Role in Sanitizing Online Exams
Rowena Viñan 475

Learning Management System for Protection of Marine Environment Course: User Feedback and Student's Academic Performance
Aldin L. Turija 491

OneUPOU: A Unified Portal for UPOU Resources
Renz Jemil Magsino 498

Beyond Written Papers: Harnessing Video Presentation for Enhanced Assessment in Online Learning
Tricia C. Ascan 504

Generative Artificial Intelligence (GenAI) Tools in Teaching English Communication Skills
Tiptida Bootchuy 514

Transforming SME Entrepreneurs in the Digital Age Based on the Concept of Lifelong Learning through Online Platforms and Artificial Intelligence
Pornprasit Denmoree 523

Development of a Lifelong Learning Platform to Promote Digital Citizenship Skills
Wachira Brahmawong 532

Needs Assessment of Digital Technology Skills Among Local Entrepreneurs in Phetchaburi Province: Preparing for The Development of a Digital Platform to Foster Innovation and Enhance Local Product Value
Thanathnuth Chatpakkarattana 541

Utilising Mobile Gamification in Emerging Digital Learning Technologies for Sustainability: A Case Study
Ratna Marta Dhewi 542

Unlocking Insights: Exploring Filipino Nursing Universities' Experience with the Filipinized Learning Management System
Rita C. Ramos 543

Smart Self-Check: Mastering Self-Regulation Through Digitally-Assisted Monitoring Tool: A Mixed Methods Study
Rita C. Ramos 545

Pioneering Care: Launching the Philippines' First Pediatric Oncology Telemedicine Initiative
Rita C. Ramos 546

Transforming Assessment in Higher Education: Cross-Border Perspectives from Romania And Republic of Moldova
Gabriela Grosseck 547

Enhancing Digital Accessibility and Quality in Open Distance Learning: SEAMOLEC's Initiatives and Regional Insights
Arie Susanty 548

Antenna Optimization for Sustainable IoT Environment
Nithizethe Mhuadthongon 549

Development of River/Drain Smart Trash Collector System
Ten Pin Zer 558

Application of Image Processing for Sign Language Interpreter
Ng Thung Xeng 569

Collaborative Learning in Pathophysiology and Pharmacology: A Case Study of Innovative Approaches in Open Distance Nursing Education
Supattra Changsuphan 582

Motivational Factor of Education Advancement in Lifelong Learning Among Late Bloomer Youth in Malaysia
Nor Azrul Mohd Zin 592

An Enhanced Productivity Prediction Model of Garment Employees Using Random Forest and SHAP Algorithm
Thanarat Pattanateepapon 593

Spatial Analysis of The Impact of Socio-Economic Factors on Higher Education
Aurora V. Lacaste 601

The Needs Assessment for Lifelong Learning of Police Officers
Pol.Col.Watcharapong Panittumrong 602

Is Sustainability Management Accounting Systems Inevitable for Leveraging Intellectual Capital Towards Sustainable Firm Performance in Digital Era? A Cross Sectional Study
Marjea Jannat Mohua 603

Factors Related to Students Drop Out in Distance Learning System in An Open University in Thailand
Sita Yiemkuntitavorn 616

Inclusive Online Learning: Recognizing and Supporting Autistic Students in Virtual Classrooms
Gunasegaran Karuppannan 617

CONFERENCE SECRETARIAT 630

CONFERENCE PROGRAM

<table>
<tr><th colspan="4">DAY 1
Wednesday, 13 November 2024</th></tr>
<tr><td>08.30-09.15</td><td colspan="2">Registration</td><td>Foyer
Phitayaphat Building</td></tr>
<tr><td>09.15-09.45</td><td colspan="2">Opening Ceremony
• Introduction of Sukhothai Thammathirat Open University
• Welcoming Address I
Assistant Professor Dr. Phanompatt Smitananda
Acting President
Sukhothai Thammathirat Open University
• Welcoming Address II
Professor Ts. Dr. Murali Raman
Deputy Vice-Chancellor
Asia Pacific University of Technology & Innovation
• Group Photo</td><td>Conference Hall
Phitayaphat Building</td></tr>
<tr><td>09.45-10.30</td><td colspan="2">Keynote Speech I
“Innovative Technology for Sustainable Lifelong Learning"
Associate Professor Dr. Ninnat Olanvoravuth
Secretary-General
Association of Southeast Asian Institutions of Higher Learning (ASAIHL)</td><td>Conference Hall
Phitayaphat Building</td></tr>
<tr><td>10.30-11.00</td><td colspan="2">Refreshment</td><td>Foyer
Phitayaphat Building</td></tr>
<tr><td>11.00-12.00</td><td colspan="2">Panel Discussion
“Envisioning Excellence: Establishing a Robust Quality Framework for Lifelong Learning"</td><td>Conference Hall
Phitayaphat Building</td></tr>
<tr><td>12.00-13.00</td><td colspan="2">Lunch</td><td>Dining Room
Seminar I Building</td></tr>
<tr><td>13.00-14.30</td><td>Parallel Session 1</td><td rowspan="2">Special Session
“Financial Innovation and Technology Towards Sustainability in the Context of Open Universities: the UPOU and STOU Experience"</td><td rowspan="3">Room 1-12
Phitayaphat Building</td></tr>
<tr><td>14.30-16.00</td><td>Parallel Session 2</td></tr>
<tr><td></td><td colspan="2">[Free Flow Refreshment]</td></tr>
</table>

CONFERENCE PROGRAM

DAY 2 Thursday, 14 November 2024			
09.00-09.45	**Keynote Speech II** "SME and Digital Business Transformation, Role of Change and Culture" **Professor Ts. Dr. Murali Raman** *Deputy Vice-Chancellor* *Asia Pacific University of Technology & Innovation*		Conference Hall Phitayaphat Building
09.45-11.15	**Special Session** "Join Forces for Impactful Advocacy – the ICDE Global Advocacy Campaign in Asia" [Free Flow Refreshment]		Conference Hall Phitayaphat Building
11.15-12.30	**Parallel Session 3**		Room 1-12 Phitayaphat Building
12.30-13.30	Lunch		Dining Room Seminar I Building
13.30-15.00	**Parallel Session 4**	**ICDE Global Advocacy Campaign – Asia Working Group Meeting** [Invited Only]	Room 1-12 Phitayaphat Building
15.00-15.30	Refreshment		Foyer Phitayaphat Building
15.30-16.30	**Closing Ceremony** • **Key Takeaways from ICDBSE2024** Professor Ts. Dr. Murali Raman *Deputy Vice-Chancellor* *Asia Pacific University of Technology & Innovation* • **ICDBSE2024 Awards Presentation** • **Closing Remarks I** Professor Ts. Dr. Murali Raman *Deputy Vice-Chancellor* *Asia Pacific University of Technology and Innovation* • **Closing Remarks II** Assistant Professor Dr. Phanompatt Smitananda *Acting President* *Sukhothai Thammathirat Open University*		Conference Hall Phitayaphat Building

SPEAKERS, PANELISTS & MODERATORS

KEYNOTE SPEAKER I

"Innovative Technology for Sustainable Lifelong Learning"

Associate Professor Dr. Ninnat Olanvoravuth

Secretary-General of the Association of Southeast Asian Institutions of Higher Learning (ASAIHL)

Education

1968 A.A. in Management, Grossmont College, El Cajon, California, U.S.A.
1970 B.A. in Finance and Economics, San Diego State University, California.
1972 MBA San Diego State University, San Diego, California, U.S.A.
1975 Ph.D. in Leadership & Organizational Behavior, U.S. International University
1983 International Teacher Program at INSEAD, Fontainebleau, France.
1984 Senior Executive Management Program, University of Calgary, Canada

Professional Experiences

1981 - Present	Secretary-General, Association of Southeast Asian Institutions of Higher Learning (ASAIHL)
2018 - Present	Chairman, Governing Board, Chalermkarnchana University
2020 - 2021	Member, Institute of Community College Council
2018 - 2024	Chairman, Governing Board, Chalermkarnchana College Rayong
2015 - 2019	Chairman, Audit Committee, Chumporn Palm Oil Public Company
2015 - 2017	Chairman, Risk Management Committee, Chumporn Palm Oil Company
2010 - 2018	Vice Chairman, Governing Board, Chalermkarnchana College Rayong
2008 - 2018	Chairman, Governing Board, Srisopon College
2008 - 2020	Member, Civil Service Commission on Human Resource Selection and Standard System
2006 - 2016	Member, Asia-Europe Education Hub Advisory Committee
2006 - 2016	Member, Administrative Committee, Chulabhorn Graduate Institute
2005 - 2011	Advisory Member, Federation of Accounting Professions

2002 - 2004	Member, National Council of Community College
2016 - Present	Member, Community College Academic Council
2001 - Present	Member, Board of Trustees, Ratchathani University
2000 - Present	Chairman, Audit Committee, A.J. Plastic Public Company
2000 - Present	Member, Recognition of Overseas Degree, Ministry of Education
2000 - Present	Member, Qualification Equivalence Determination Committee
2012 - 2016	Member, International Advisory Council of Universiti Tenaga Nasional
1998 - 2018	Member, Board of Trustees, Udon Ratchathani University
1994 - 2018	Founding Member, Association of Universities in Asia and the Pacific
1992 - 2021	Member, Personnel Committee, Suranaree University of Technology
1985 - 2005	Member, Accreditation Committee, Ministry of University Affairs
1981 - 2018	Member, Governing Board, SEAMEO-RIHED
1999 - 2000	Member, Board of Trustees, Yonok University
1996 - 2001	Member, Board of Trustees, Stamford International University
1993 - 1996	Member, Board of Trustees, University Maryland University College
1991 - 1999	Founding Member, University Mobility in Asia and the Pacific (UMAP)
1990 - 2003	Member, Board of Trustees, Krirk University
1988 - 2000	Member, Board of Trustees, Southeast Asia University
1983 - 2002	Member, University Development Commission (UDC)
1968 - 1975	Assistant Manager & Center Cashier, United Parcel Service of America San Diego, California. U.S.A.

Awards and Achievements

Distinguished Professor of International Business at Adam Smith University
Honorary Professor at Heidelberg College
University Professor at Soka University
Visiting Professor at Institute for International Studies and Training (IIST) Japan
Knight Grand Cross (First Class) of the Most Noble Order of the Crown of Thailand
Knight Grand Cross (First Class) of the Most Exalted Order of the White Elephant
Knight Grand Cordon (Special Class) of the Most Noble Order of the Crown of Thailand
Knight Grand Cordon (Special Class) of the Most Exalted Order of the White Elephant

KEYNOTE SPEAKER II

"SME and Digital Business Transformation, Role of Change and Culture"

Professor Ts. Dr Murali Raman

Deputy Vice Chancellor,

Director Postgraduate & Continuing Education

Asia Pacific University of Technology & Innovation

Professor Ts. Dr. Murali Raman is both a Rhodes Scholar and Fulbright fellow. His academic credentials include a Ph.d. from SISAT, Claremont, USA; M.B.A. (Imperial College, London); M.Sc. Human Resources (London School of Economics, UK).

With his research team, Dr. Murali and his team has secured close to RM1.5Million in grant funding over the last five years. He is affiliated to Stanford's Technology Venture Program as a Faculty Fellow- where he has had and continues to discuss issues surrounding creating a vibrant entrepreneurship ecosystem and application of innovative thinking via Design Principles in Malaysia. He is a Stanford certified Design Thinker, and was attached to the Stanford Technology Venture Programme as a Faculty Fellow.

Prof. Murali Raman is also certified in Neuro Linguistic Programming (NLP) – 2016 as an NLP Certified Practitioner. He is also a Certified Trainer in Colored Brain Communication and Emotional Drivers based on Directive Communication Psychology. He is also a Fellow with the Malaysian Institute of Management (MIM).

Throughout his career in the corporate and academic sector, Prof. Murali has managed, led and directed numerous programmes in relation to digital transformation. With Accenture Consulting he managed a total of nine [9] projects of which three were in Singapore with Tier 1 clients.

Prof. Murali continues to consult and assist corporations to transform digitally, using design thinking and business model canvassing ideas. In recognition of his leadership, Prof. Murali has received several accolades at an International level. Examples are:

- European Champion for Knowledge Management Systems, 2019, Lisbon Portugal

- Outstanding Academic Leadership Award in Malaysia – 2016 EDUCOOP for IT Management
- Innovation Gold Medallist, iCAN, Canada, 2019
- Innovation Gold Medallist for 21st Century Teaching, 2019, Sri Lanka
- World Innovation Award – Seoul, Korea – 2015
- Augerah Pecipta Negara – Gold Medal
- Golden Globe Tiger Awards – For Outstanding Academic Leadership

He has published more than 130 papers in International Journals, Conferences, and Book Chapters. He was appointed as a lead consultant and author of Malaysia's Social Innovation Roadmap, by Yayasan Inovasi under MOSTI. He also serves as the CEO of an NGO called Sathya Sai Academy for Human Values—an academy which focusses on promoting human values-based education in Malaysia. He also serves as a Board member of the Malaysian Private Education Cooperative (EDUCOOP).

He continues to do research, train and teach in areas such as digital business transformation, design thinking and applications of IT in organisations.

Prof. Murali also serves as an Editorial Board Member for several leading SCOPUS indexed journals including the British Journal of Education Technology (BJET). He serves as Adjunct Professor with several leading universities in Malaysia (e.g. Taylors University, MMU and MSU) and abroad (Chitkara University, and Jansson Business School, India).

PANEL DISCUSSION

Envisioning Excellence: Establishing a Robust Quality Framework for Lifelong Learning

PANELISTS

Professor Drs. Ojat Darojat, M.Bus., Ph.D.

President of the Asian Association of Open Universities (AAOU)

Rector of Universitas Terbuka, Indonesia

Prof. Ojat Darojat, M.Bus., Ph.D., has been serving as the Rector of Universitas Terbuka (UT) since July 26, 2017, and was reelected for a second term from 2021 to 2025. He has significantly contributed to expanding access to higher education in Indonesia, earning numerous accolades for his efforts, including the Best University Leader in the Obsession Awards 2023 and recognition as the best education leader in Asia for 2022 by CEO Insight Asia magazine.

He also holds the position of President of the Asian Association of Open Universities (AAOU) for the second consecutive term 2023-2025 and ICDE Focal Point of Quality Network for the Asian region.

In addition to his administrative roles, he has a strong academic background with various publications focusing on quality assurance in distance education, entrepreneurship, curriculum of blended learning, and the implementation of technological infrastructure in distance higher education institutions. He has also served as a reviewer for international journals and participated in various educational organizations globally.

Torunn Gjelsvik

Secretary General of the International Council for Open and Distance Education (ICDE)

Torunn Gjelsvik from Oslo, Norway, is the Secretary General of ICDE – the International Council for Open and Distance Education. With specialization in open, flexible, distance and online learning. Torunn is a strong advocate for inclusive, scalable and sustainable education and lifelong learning opportunities for all.

Gjelsvik holds a Masters' degree in Nordic languages and literature, and her education background includes French, History, Management and Strategic communication. She started working with the development of distance and online education in 2000, and has held various national and international leadership positions within the field.

Gjelsvik's international experience covers advocacy, policy advice, international networks and partnerships, global events and cross-country project management related to the global field of open, flexible, distance and online education. She is often seen as a speaker or panelist at international education conferences around the globe.

About the International Council for Open and Distance Education - ICDE

The International Council for Open and Distance Education (ICDE) is the leading, global membership association working to bring inclusive, quality education to all. Through its global membership, ICDE impacts millions of students, shares knowledge and best practices, facilitates intercultural collaboration, and advocates for inclusive learning worldwide. As a long-standing consultative partner to UNESCO, ICDE and its members work globally and regionally to achieve UN Sustainable Development Goal 4: Equitable quality education for all.

ICDE also regularly organizes the ICDE World Conference, widely recognized as the leading international conference for Open, Flexible and Distance Learning (OFDL). The conference has been hosted by ICDE members around the world since the organization's inception in 1938.

Datuk Dr. Habibah Abdul Rahim

Director of the Southeast Asian Ministers of Education Organization (SEAMEO) Secretariat

Datuk Dr. Habibah Abdul Rahim is currently Director at SEAMEO Secretariat (Southeast Asian Ministers of Education Organization Secretariat) (1 April 2023 to 31 March 2027). She is also an Honorary Fellow at MASA Institute, Senior Advisor of Edvolution, and Board Member of Teach for Malaysia Foundation and Dewan Bahasa and Pustaka.

Datuk Habibah is the former Director General of Education Malaysia and has served the Ministry of Education Malaysia for more than 34 years before retiring on 6 April 2021. She began her career as a secondary school teacher and some of the posts she subsequently held include Head of the Delivery Management Office for the Executive Director of the Education Performance and Delivery Unit, Director of the Educational Planning and Research Division, and Deputy Director General of Education (Policy and Curriculum). She has extensive experience in policy development, macro planning, programme implementation and evaluation. She played an instrumental role in the development of the Malaysia Education Blueprint 2013-2025, Education Development Master Plan 2006-2010 and Education Development 2001-2010.

Her publications (with other authors) include: 21st Century Competencies and Structural Education Reform, in APEC 2018 Report on Education and Economic Development (2019); Model, Instruments and Unity Index and their Impact on the Unity Policy, in Creative Education 2019, 10(12); and Formulating Policies for Gender-Responsive STEM Education, in IBE-UNESCO (2017), A Resource Pack for Gender-Responsive STEM Education.

MODERATOR

Professor Dr. Abtar Kaur Darshan Singh

Harnessing Innovations in Technology to Support Teachers and Quality Learning: APU-UNESCO Chair

Professor, Innovation Digital Learning of Asia Pacific

University of Technology & Innovation

Prof. Abtar Darshan Singh, a distinguished academic and researcher, has demonstrated exemplary leadership in the field of education. With a rich background in educational technology, and related areas, Prof. Singh's career spans over three decades, marked by her tenure as a Dean and Professor at prominent universities. She is an alumni, educator, and leader at Hamdan Bin Mohammed Smart University (Dubai), University Malaya and Open University Malaysia (Malaysia) and Syracuse University and Indiana University (USA). Her expertise encompasses a diverse range of educational disciplines, including instructional and curriculum design, teacher training, and digital learning technologies. She is currently an Advisor to the Digital Learning Hub at the APU. Prof Singh also holds the UNESCO Chair at APU on: *Harnessing Innovative Technologies to Support Teachers and Quality Learning*.

A prolific writer, Prof. Singh has authored numerous scholarly articles and books, contributing significantly to the discourse on educational innovation and reform. Her research has focused on addressing contemporary challenges in education, particularly in the context of globalization and technological advancements.

Prof. Singh's commitment to educational advancement is further evidenced by her active participation in international conferences and forums. She has served as a keynote speaker and panelist, sharing her insights on educational policies, digital learning, and innovative practices globally. Her contributions extend beyond academia, as she has been instrumental in advising government and non-governmental bodies and educational institutions on policy formulation and implementation related to education and specifically digital learning.

Over the past 3 decades, Prof. Singh has provided community service, consultancy, and training under the auspices of the World Bank, UNESCO, UNDP, and the Commonwealth of Learning (COL) to educators worldwide. As a Fulbright Scholar, she has contributed enormously towards cultural and community development initiatives. She supports Special Education Needs (SEN) projects under *Kiwanis Malaysia* and community development under the banner and initiatives of *The Malaysian Association of Yoga Instructors*.

SPECIAL SESSION

The ICDE Global Advocacy Campaign on OFDL in Asia

PANELISTS

Torunn Gjelsvik

Secretary General of the International Council for Open and Distance Education (ICDE)

Torunn Gjelsvik from Oslo, Norway, is the Secretary General of ICDE - the International Council for Open and Distance Education. With specialization in open, flexible, distance and online learning. Torunn is a strong advocate for inclusive, scalable and sustainable education and lifelong learning opportunities for all.

Gjelsvik holds a Masters' degree in Nordic languages and literature, and her education background includes French, History, Management and Strategic communication. She started working with development of distance and online education in 2000, and has held various national and international leadership positions within the field.

Gjelsvik's international experience covers advocacy, policy advice, international networks and partnerships, global events and cross-country project management related to the global field of open, flexible, distance and online education. She is often seen as a speaker or panelist at international education conferences around the globe.

Professor Dato' Dr. Ansary Ahmed

Founder President of Asia e University

Prof. Dato' Dr. Ansary Ahmed, is a Malaysian academic entrepreneur. He is the Founder President and presently the Group Managing Director of the Asia e-Learning Pvt Ltd the license holder of Asia e University (AeU), a collaborative multinational university initiated by the Asian Cooperative Dialogue.

Prof. Dato' Dr. Ansary has served in numerous national and international level committees. Internationally, Prof. Dato' Dr. Ansary was a member of UNESCO Kornberg 21st Century Visionaries for Higher Education and served as a UNESCO Technical Consultant, specifically online education. He has represented Malaysia as a member of the Board of Trustees ASEAN University Network for several years. **He served as a member of the Asian Association of Open Universities Executive Board for one term. He has on occasions acted as an International elearning consultant with Booz Allen Hamilton. He was the Project Co-Director for Total elearning Solution, Ministry of Higher Education, Kingdom of Saudi Arabia, and has served as Honorary Advisor for Asia under the Commonwealth of Learning, Vancouver, Canada for several years. He was elected into and served as a Board member of the International Council for Distance Education based in Norway from 2018-2021. He is also an Executive member of the Asian Cooperative Dialogue (ACD) University Network since 2017. Most recently he was appointed as a Governing Board Member of the UNESCO International Institute for Information Technology in Education.**

At a national level, Prof. Dato' Dr. Ansary has been actively involved as a Steering committee member of the National Biotechnology Group. He served as Special Science Officer at the Science Advisor Office, Prime Minister's Department for 6 years. He also served as a member of the Task Force National Technology Mapping Project, National Innovation Systems and Headed the Pharmaceutical Secretariat at the Malaysian Industry Government Group for High Technology (MIGHT) in the Prime Ministers' Department.

Prof. Dato' Dr. Ansary also served on the Science Council of the Malaysian Agriculture Development Institute Malaysia (MARDI) for over 6 years. He had also served as a Project leader for Evaluation of Intensification of Research Priority Areas under the Malaysian Academy of Sciences, and as a Member on Study on Post-Industrial Master Plan; Malaysian Institute of Economic Research (MIER).

Prof. Dato' Dr. Ansary has served as Chairman and member of several national level task forces and committees in the Ministry of Higher Education, Malaysia. He was **National Chairman for Internationalisation**, **National Chairman for elearning, involving all the Malaysian public Universities, polytechnics as well as all the community colleges, in which a National elearning road map was developed and implemented**.

He currently serves as a member of National Lifelong Learning Council. He is a long serving member of the Education Committee of the Asian Institute of Charted Banker and served as a Task Force Member for the establishment of the Asian Banking School, and is presently a Task Force Member of the Transformation of the Banking Sector, as well as Task Force Member for the Financial Accreditation Agency, both under the auspices of The Central Bank Malaysia. He also serves as an executive committee member of the British Malaysian Chamber of Commerce Higher Education Committee and served on the executive Committee of Malaysian Private Universities Vice Chancellors Council from 2018-2021. He is also a long serving ambassador for Education Tourism under the Ministry of Tourism, Malaysia since 2016.

He has long been an active serving member of the State Religious and Malays Customs Council under the Sultan of Perak, Malaysia. He has served as the Chairman of the Audit Committee and presently is the Chairman of the Risk Management Committee, Chairman for Research and Development Committee and a Member of the Audit and Entrepreneurship Committee.

Prof. Dato' Dr. Ansary obtained his PhD from the University of Manchester, United Kingdom, specializing in Molecular Genetics. He started his academic career as a tutor at the Department of Genetics and Cellular Biology, University of Malaya in 1979. He was promoted to full Professor in 1994 and was the Founder Dean of Institute of Graduate Studies until 2002. Upon taking optional retirement he was appointed the Senior Vice President and became the Co-founder of Open University Malaysia, the largest ODL University in Malaysia.

Prof. Dato' Dr. Ansary was the recipient of the **Most Promising Entrepreneur** by Enterprise Asia in 2010 in recognition of AeU's great success as a Startup. He was awarded **Honorary Associate Fellow of Institute of Bankers Malaysia** by the Central Bank Malaysia for his long service in 2012. In recognition of his vast contributions to e-education, he was **ASEAN Master class leader in e-education development (2018)** and is the **FIRST recipient of** the **National e-learning Maestro Award (2018)**. Most recently, Prof Ansary was conferred an **Honorary Doctorate in Education by Siam University,** Thailand (2020) for his international contribution in higher education.

He was conferred the **Champion of State** from the State of Penang by the Governor in 2005, and in 2007 the **Darjah Paduka Mahkota Perak** from the Sultan of Perak, which carries the title Dato'.

Melinda dela Peña Bandalaria

Chancellor of the University of the Philippines Open University

Dr. MELINDA DELA PEÑA BANDALARIA is full professor at the University of the Philippines Open University (UPOU) and has been its Chancellor since 2016. Her international engagements include being an Ambassador for Open Educational Resources (OERs) (2021-2024) and a member of the Executive Board (2022-2025) of the International Council for Open and Distance Education (ICDE); member of the Governing Board of the SEAMEO Regional Open Learning Centre (SEAMOLEC) (2022-2025); member of the Executive Committee of the Asian Association of Open Universities (AAOU); and member of the Advisory Group of UNESCO's OER Dynamic Coalition. She also served as AAOU President from 2017-2019. She spearheaded the development and offering of Philippine MOOCs model (PHMOOCs), which made ChatGPT refer to her as the "Mother of Philippine MOOCs". Her current initiatives include harnessing the synergy of the MOOCs and micro credentialing frameworks for inclusive, accessible, and quality lifelong learning opportunities as a strategic model for sustainable education ecosystem.

Her experience in Open Flexible and Distance eLearning (OFDeL) spans more than 25 years and her contributions had been recognized through the Meritorious Service Award conferred by the AAOU in 2021; and the Prize of Excellence conferred by the ICDE also in 2021.

Dr. John Cribbin

Deputy Director (Academic Services) of University of Hong Kong School of Professional and Continuing Education (HKU SPACE)

John Cribbin graduated from UCL and holds a masters from Leicester and an Ed.D. from Nottingham. In 2019, he was awarded a Fellowship of the University of London.

He has worked at King's College London, the UK Open University and the University of Hong Kong. At HKU he has worked in the Registry, the Faculties of Education and Arts and HKU SPACE.

HKU SPACE is a self-financed, not-for-profit university company limited by guarantee. In 2023-24, HKU SPACE had an enrolment of more than 95,000, involving 63,192 individuals which is equivalent to 20,088 FTEs, including 11,935 full-time students, a staff of around 880 and an income of more than HK$1 billion.

His major duties include corporate governance as the Company Secretary and academic governance as head of registry affairs, quality assurance and enhancement and the Maisy Ho Centre for Teaching and Learning. He serves on the school's senior management team.

He has published in the field of lifelong learning and transnational education and has made several conference presentations. He also represented Hong Kong at the Asian Cricket Council and International Cricket Council and served on several of their committees while Secretary and Chairman of Cricket Hong Kong until 2019. He is married with three children.

FULL PAPERS

SUB-THEME 1
DIGITAL BUSINESS & ECONOMY

THE IMPACT OF DIGITAL BUSINESS INVESTMENT ON INCOME, EMPLOYMENT, AND ECONOMIC GROWTH IN THE THAI ECONOMY

Anucha Wittayakorn-Puripunpinyoo[A]

ABSTRACT

For the past decade, Digital business has played a key role in the Thai economy. It is the utilization of various technologies to develop businesses aimed at enhancing convenience for both entrepreneurs and consumers in selecting products or services. Digital business investment has been and is still the source of income, employment, and economic growth in the Thai economy. The research objectives were to: 1) examine the impact of digital business investment on income, 2) examine the impact of digital business investment on employment, and 3) examine the impact of digital business investment on economic growth in the Thai economy. The monthly time-series data were collected from the Bank of Thailand and Ministry of Digital Economy and Society from 2014 to 2023 with 120 observations. The econometric model was established for data analysis. The findings exhibited that an increase in digital business investment by 1 percent, then it will lead to an increasing in income by 0.069 percent. In addition, an increase in digital business investment by 1 percent will lead to an increase in employment, and economic growth by 0.603 and 0.260 percent respectively. Digital business encompasses the integration of digital technologies to innovate and enhance various aspects of business operations. This includes processes, products, and services, as well as functions like marketing, sales, and customer service. By leveraging digital technology across the entire value chain, businesses can streamline operations, improve efficiency, and deliver better experiences for customers.

Keywords: *Digital Business Investment, Income, Employment, Economic Growth, Thai Economy*

INTRODUCTION

In 2017, Thailand embarked on a comprehensive journey towards a digital economy, driven by government policies aimed at fostering the growth and utilization of digital innovations. This strategic move aims to propel the nation out of economic and social development challenges. Furthermore, the Digital Development for Economy and Society Act of 2017 underscores critical aspects essential to achieving these objectives, such as the promotion of industries and innovations, fostering investments, and leveraging digital technologies for both economic and social advantages, along with enhancing the country's digital workforce (Digital Economy Promotion Agency of Thailand, 2024).

When comparing global digital capabilities, Thailand is still at a mid-level, ranking the 41st out of 63 countries in the World Digital Competitiveness Ranking and the 62nd out of 139 countries in the Networked Readiness Index 2016 (NRI) by the World Economic Forum.

[A] *Ph.D, School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: puanucha@windowslive.com*

Thailand is ranked the 3rd in ASEAN. Overall, Thailand's strengths include a high number of mobile internet users, a strong digital export market, and a robust economic environment, particularly in the financial sector. Areas that are performing well but still require improvement include the adoption of digital technology in business sectors and the enhancement of digital laws and regulations. Urgent weaknesses that Thailand needs to address include the very low digital skills of the general population and workforce, the lack of digital innovation or research and development of marketable products and services, high investment risks, and challenges with intellectual property protection.

In business terms, some sectors have begun adapting to the digital economy by shifting to online business channels such as e-commerce. The value of Thai digital business in 2024 reached $280 billion. However, for most Thai digital businesses that are not primarily e-commerce, the adoption of basic digital technologies remains suboptimal. According to the Office of Small and Medium Enterprises Promotion, Thailand (2024) reported that although Thailand had over 2.7 million SMEs in 2024, accounting for 99.7% of all enterprises and employing 10.5 million people accounted for 80.30 percent of the total employment. They generated only $577 billion accounted for 39.60 percent of the Thai Gross Domestic Product (GDP).

In Thailand, the digital business is a rapidly evolving sector that continually adapts to the swift advancements in technology. It has grown from the traditional Information and Communication Technology (ICT) industry. To promote the digital economy, the digital business is broadly defined to include manufacturing and various service industries related to or benefiting from digital technology. It encompasses five branches of the digital business which comprised of hardware & smart devices, software and communications, digital services, and digital content industries.

However, despite continuous growth of digital business in Thailand yearly, there are still limitations to this growth. Medium and small-scale e digital business often lack the capital to expand their businesses and find it difficult to obtain loans. Additionally, most digital businesses are considered too risky for banks to accept. Furthermore, the digital business lacks investment in innovation that could lead to high-value products and services. Particularly, there is a lack of connection between digital research and development and the target industrial sectors of the country.

The Digital Economy Promotion Agency (DEPA) was founded in accordance with the Digital Development for Economy and Society Act 2017. Its primary objective is to foster the growth of the digital industry and innovation landscape. DEPA endeavors to facilitate the widespread adoption of digital technology, aiming to contribute positively to the nation’s economy, society, culture, and security. Oversight of DEPA falls under a Board of Commissioners, with members appointed by the Ministry of Digital Economy and Society.

From 2015 to 2024, Thailand's digital business sector still holds significant growth potential, as indicated by recent findings estimating that the value of goods and services procured through digital platforms known as business-to-consumer is projected to reach $99,444 Billion yearly. Its growth rate was 17.90 percent annually The digital business is currently worth $2.20 trillion accounting for 13.0 percent of Thai Gross Domestic Product (GDP). (www.bangkokpost.com/life/tech).

Digital Business refers to the use of digital technologies and resources to drive day-to-day business operations, develop revenue and performance and deliver personalized, meaningful experiences to customers (McKendrick, 2020). In digital business, digital technologies are employed in all areas of the business, to optimise internal and external processes and business activities. Digital business models employ technologies to deliver not only better products and services, but to also personalized, meaningful experiences to

customers. New models may also replace once-and-done offerings with subscription-based services or opportunities. Or, new types of services are made available on demand to customers. Notice the common denominator here — it's all benefiting, and perhaps even wowing, the customer. Replacing live customer service reps with Chabot's will not wow customers, or add much other value other than labor cost-savings. Predictive analytics may help keep production lines running, but that's a minimal expectation for customers.

Digital business is changing the way organizations use and think about technology, moving technology from a supporting player to a leading player in innovation, revenue and market growth (Gartner, 2014). Digital business has emerged rapidly in Thailand, arriving much sooner than initially anticipated by the business sectors. Despite this accelerated arrival, digital businesses have seamlessly integrated into Thai society, enhancing the convenience of everyday life for typical consumers. Financial technology and its services have become integral to daily transactions, with the increasing popularity of blockchain and cryptocurrencies further boosting their prominence (www.statista.com).

Additionally, digital businesses have made substantial investments in digital services, concentrating on e-logistics, e-retail, and online media to improve customer experience. They are also channeling resources into e-advertisements, recognizing that consumers are spending an increasing amount of time online. (www.statista.com)

In addition to recent events that have accelerated Thailand's digital transformation, the government is actively promoting digital integration through the Thailand 4.0 economic scheme. This plan aims to enhance value-based productivity through innovation and reposition traditional businesses with smart technology. However, Thailand faces challenges such as a shortage of digital professionals and increasing risks of cyberattacks. Despite these hurdles, the country has increased spending on cybersecurity. Furthermore, the government has launched digital training programs and platforms in collaboration with private sector partners to upskill workers, preparing Thailand for the new digital era. (www.statista.com) Value of digital market in Thailand $6.667 Billion Growth of digital business in Thailand 14% (www.statista.com)

LITERATURE REVIEW

1. Digital technology investments

Digital technology investments involve allocating financial resources to acquire and implement new technological tools and systems that enhance business operations. These investments aim to boost efficiency, productivity, and competitiveness in a constantly evolving technological landscape. IT departments play a crucial role in implementing these investments, as they possess the technical expertise needed to integrate new tools into existing infrastructure.

These investments can include hardware, software, and cloud-based solutions that improve various business processes, such as communication, data management, and customer experience. The success of these investments is measured by their ability to generate measurable returns on investment. Digital technology investments play a critical role in promoting the growth and success of digital businesses in today's economy with the following items:

Digital technologies, such as automation, Artificial Intelligence (AI), and Machine Learning (ML), can streamline business operations and enhance operational efficiency. By automating repetitive tasks, businesses can achieve faster turnaround times with fewer errors. AI and ML algorithms offer valuable insights for process optimization and error reduction, leading to more efficient and effective operations.

Digital technology investments enable businesses to collect and analyze large volumes of data, making data-driven decisions with advanced analytics tools. AI and ML algorithms help identify patterns in the data that would be otherwise impossible to detect manually. These advanced analytics tools also facilitate accurate forecasting and predictive analysis, allowing businesses to respond proactively to market changes and opportunities. Companies that invest in digital technology gain a competitive edge over their peers. By leveraging digital technologies, businesses can deliver products and services that meet customer needs more efficiently, quickly, and cost-effectively. Additionally, they can offer personalized experiences, fostering customer loyalty and driving growth.

Digital technology investments can lead to significant cost savings by reducing manual labor, streamlining processes, and improving productivity. For example, cloud computing allows businesses to access scalable computing resources as needed, eliminating the need for costly infrastructure investments.

Businesses should invest in various digital technologies to ensure their operations remain competitive and efficient. These investments should include the latest hardware, software, cloud-based solutions, and applications that can help accelerate business operations. Businesses should also consider investing in AI and ML algorithms and data analytics tools to gain insights into customer behavior and market trends. Outlined are five trending investment opportunities for businesses aiming to maintain a competitive edge:

1. Prioritize Mobile-First User Experience: Given that over half of website traffic originates from mobile devices, businesses must prioritize mobile-friendly interfaces. Google's search algorithm favors mobile-optimized websites, necessitating companies to ensure their platforms are mobile-responsive to attain high search engine rankings. This entails designing user-friendly and visually captivating mobile interfaces, optimizing load times, and delivering an exceptional mobile experience for visitors. Additionally, businesses should explore developing mobile applications to elevate customer experience, foster loyalty and engagement, and offer a distinctive value proposition.

2. Quantum Computing: Quantum computing, an emerging technology, has the potential to transform computing by executing complex calculations exponentially faster than classical computers. This advancement can be a game-changer for businesses requiring extensive computational power, particularly in industries such as finance, healthcare, and logistics. Quantum computing operates on the principles of quantum mechanics, enabling the creation of qubits (quantum bits) that can exist in multiple states simultaneously. Investing in quantum computing can provide businesses with a competitive advantage by accelerating research and development capabilities, enhancing decision-making processes, and improving operational efficiencies. Businesses can leverage quantum computing to develop innovative applications and tackle intricate problems previously deemed impossible or impractical.

3. Digital Transformation: Digital transformation is a multifaceted process involving the integration of modern digital technologies across all aspects of a business. By adopting these advanced tools and platforms, companies can achieve significant operational efficiencies, streamline processes, cut costs, and enhance their offerings to meet evolving customer needs. Investments in digital transformation can encompass various initiatives, such as implementing cloud-based solutions, upgrading legacy IT systems, automating manual processes, and leveraging data analytics for customer insights. By embracing these cutting-edge technologies, businesses can drive innovation and gain a competitive advantage in their markets. Digital transformation goes beyond technology implementation; it requires a strategic shift in how a business operates and delivers value to customers. This entails a cultural transformation within the organization and a concerted effort to upskill and reskill the workforce to remain ahead of the curve. Continued investment in digital transformation enables businesses to stay agile and

adaptable in response to changing market conditions. By anticipating and addressing evolving customer needs, companies can enhance the overall customer experience, driving growth and profitability.

4. AI and Advanced Analytics: Managing and analyzing data from multiple sources can be overwhelming and time-consuming, potentially leading to missed business opportunities. However, with the integration of AI and advanced analytics, businesses can access valuable insights, automate repetitive tasks, and enhance customer satisfaction. Technologies such as big data, machine learning, and natural language processing empower organizations to uncover hidden patterns, trends, and predict future outcomes. By processing vast amounts of data quickly, businesses can make informed decisions that yield better results. Investing in AI and advanced analytics offers several benefits, including the ability to personalize the customer experience. By analyzing customer data, businesses can tailor offerings to individual preferences, behaviors, and needs, fostering stronger customer relationships and increased loyalty. Moreover, these technologies streamline operations by automating manual tasks, thereby freeing up employee time. Another advantage is the provision of real-time data insights, enabling businesses to make informed decisions that drive better outcomes. For example, analyzing sales data facilitates predicting future demand, optimizing pricing and inventory management, and mitigating stockouts.

5. Cloud Migration: As businesses expand, the importance of a reliable, flexible, and secure IT infrastructure grows. Cloud migration entails transferring business applications and data to cloud-based infrastructure, offering organizations benefits such as reduced maintenance costs, improved scalability, enhanced security, and increased flexibility. To migrate to the cloud, businesses need to select the right cloud provider, evaluate their existing IT infrastructure, devise a migration plan, and execute the migration. By investing in cloud migration, businesses can leverage the latest technology and gain a competitive advantage. Cloud infrastructure provides several advantages, including decreased maintenance costs, heightened security, and enhanced scalability. Moreover, cloud migration enables businesses to swiftly adapt to changing market conditions. With improved scalability, companies can easily adjust their resources as required without the need for significant investments in new hardware or software, granting them the agility to respond promptly to market demands.

2. Gross Domestic Product (GDP) as National Income of Thai economy

Over the past four decades, Thailand has achieved significant social and economic progress, transitioning from a low-income to an upper-middle-income country in less than a generation. This transformation has established Thailand as a notable development success story, characterized by sustained robust growth and substantial poverty reduction. (World Bank Group, 2024).

From 1960 to 1996, Thailand's economy grew at an impressive average annual rate of 7.50 percent. Even after the Asian Financial Crisis, the economy continued to expand, achieving an average growth rate of 5.0 percent from 1999 to 2005. This economic growth created millions of jobs, lifting millions of people out of poverty (World Bank Group, 2024).

Thailand's economy heavily relies on exports, which accounted for approximately 58% of the country's Gross Domestic Product (GDP) in 2024. As a newly industrialized country, Thailand had a GDP of US$495 billion in 2024, making it the 9th largest economy in Asia. As of 2024, Thailand maintained an average inflation rate of 1.06 percent and an account surplus equivalent to 7.5 percent of its GDP. Additionally, the Thai Baht ranked as the tenth most frequently used global payment currency (International Monetary Fund, 2024).

The industrial and service sectors are the primary contributors to Thailand's Gross Domestic Product (GDP). The industrial sector accounts for 39.20 percent of GDP, while the

agricultural sector contributes 8.40 percent (Bank of Thailand, 2024). In comparison, the trade and logistics and communication sectors account for 13.40 and 9.80 percent of GDP, respectively (Central Intelligence Agency, 2024). The construction and mining sector adds 4.30 percent to the GDP. Other service sectors, including financial services, education, and the hotel and restaurant industries, make up 24.90 percent of the GDP. Telecommunications and trade in services are emerging as key areas for industrial expansion and economic competitiveness. Also, the digital business transaction was accounted for 17 percent of GDP (World Trade Organization, 2024).

The World Bank recognizes Thailand as one of the great development success stories in terms of social and development indicators. Despite having a per capita gross national income (GNI) of US$7,090 and ranking 66th in the Human Development Index (HDI), the country has made significant strides in reducing poverty. According to the Office of the National Economic and Social Development Council's (NESDC) new poverty baseline, the percentage of people living below the national poverty line dropped from 65.26 percent in 2014 to 8.61 percent in 2023.

Thailand boasts one of the lowest unemployment rates in the world, reported at just one percent for the first quarter of 2024. This low unemployment rate is largely attributed to a significant portion of the population being engaged in subsistence agriculture or other forms of vulnerable employment, such as own-account work and unpaid family work (The Office of the National Economic and Social Development Council, 2024), (Central Intelligence Agency, 2024).

3. Employment in Thai economy

Employment is a contractual relationship between two parties where one party, the employer, compensates the other party, the employee, for performing designated tasks. The employer, which can be a corporation, nonprofit organization, cooperative, or other entity, pays wages to the employee. These wages can be based on an hourly rate, piecework, or an annual salary, depending on the job type, industry standards, and the bargaining power of both parties. In certain sectors, employees may also receive gratuities, bonuses, or stock options. Additionally, some employment types offer benefits like health insurance, housing, and disability insurance. Employment is typically governed by employment laws, organizational policies, or legal contracts (Stephen, D. & Scott, A. J., 1989). An employee provides labor and expertise to support the efforts of an employer or an individual managing a business or project (Richard, A., Kerry, b., Travers, M., & Ruschena, L., 2017)

An employee is typically recruited to fulfill particular responsibilities outlined within a job description. In a corporate setting, an employee is an individual engaged to offer services to a company regularly in return for compensation, and does not provide these services as an independent business entity (Ristau, R., A., 2010).

Researchers have discovered evidence indicating that growth in manufacturing and services has a positive impact on employment. They observed that while GDP growth has a limited effect on employment in agriculture, growth in value-added has a comparatively larger impact (Melamed, C., Hartwig, R., & Grant, U., 2011). The impact on job creation varies across different industries and economic activities, with varying levels of evidence and key studies supporting these findings. For the extractives sector, extensive evidence suggests that growth has a limited impact on employment. Conversely, in the textiles sector, although the evidence is limited, studies indicate that growth has positively contributed to job creation. Similarly, for agri-business and food processing, research has found that growth in these areas has a positive impact on job creation (Basnett, Y., & Ritwika, S., 2013).

Research showed that different industries and economic activities have varying impacts on job creation, supported by different levels of evidence and key studies. In the extractives sector, there is substantial evidence indicating that growth has a limited effect on employment. However, in the textiles sector, although evidence is not as abundant, studies suggest that growth has a positive impact on job creation. Similarly, for agri-business and food processing, research indicates a positive relationship between growth and job creation (Basnett, Y., & Ritwika, S., 2013).

The majority of existing literature primarily concentrates on OECD and middle-income countries, where the impact of economic growth on employment has generally been demonstrated to be positive. However, researchers found insufficient evidence to draw conclusions regarding the impact of growth on employment in Least Developed Countries (LDCs), with some studies suggesting a positive impact and others highlighting limitations. They recommended that complementary policies are essential to ensure that economic growth positively influences employment in LDCs. Regarding trade, industry, and investment, the evidence of a positive impact on employment from industrial and investment policies is limited. While substantial bodies of evidence exist for other aspects, such as trade, the precise impact remains disputed (Basnett, Y., & Ritwika, S., 2013).

4. Employment in Digital Business

Digital businesses typically involve performing information-based tasks such as content marketing, email marketing, e-commerce (buying and selling products and services online), and connecting people through social media, among others. This sector is among the fastest-growing, as the digital economy continues to create new products, services, platforms, and networks, resulting in an array of new job opportunities (www.linkedin.com).

Digital businesses are generated through the utilization of information and communications technologies (ICT) in both existing and novel activities and processes. The fundamental ICT tools essential for digital jobs include computers, smartphones, databases, and the internet. These tools are indispensable for manipulating, managing, and disseminating information, thereby facilitating the execution of various digital tasks and roles (www.linkedin.com).Digital employments encompass a wide spectrum, ranging from full-time to part-time positions, and can be carried out either remotely from home or within an office setting. The simplicity of digital jobs can vary greatly, from tasks as basic as monitoring someone's updates on Facebook to more intricate responsibilities such as orchestrating digital marketing campaigns, programming computer code, or employing sophisticated tools to analyze big data projects (www.linkedin.com).

In addition, the digital business revolution is reshaping numerous facets of life, particularly the workplace. Digital skills have become increasingly crucial, with many hiring managers considering proficiency in this area as essential for their future workforce. Present-day digital careers encompass a wide array of pathways, ranging from roles in digital media marketing to the design and development of mobile applications, among others (www.linkedin.com). Nevertheless, as the landscape of work evolves, individuals hold varying opinions about how these changes will impact them. Employment in digital positions presents both opportunities and challenges, akin to traditional jobs. Ultimately, the experience hinges on individual needs and preferences (www.linkedin.com).

5. Economic Growth

Economic growth refers to the expansion of economic goods and services production over a certain period, compared to a previous timeframe (Congressional Research Service, 2024). It's typically assessed in nominal or real terms, often through metrics like Gross

Domestic Product (GDP), although other measures are sometimes utilized. Essentially, it denotes a boost in overall production within an economy, typically resulting in higher national income. This uptick in production often aligns with increased average marginal productivity, leading to higher incomes and prompting consumers to spend more, thus enhancing material quality of life and living standards (Investopedia, 2024) , (Congressional Research Service, 2024).In economic models, growth is often depicted as a function of physical capital, human capital, labor force, and technology. Augmenting the quantity or quality of the working-age populace, their tools, and the methodologies for combining labor, capital, and resources tends to amplify economic output (Kunal, S., 2024).

The economy experiences various phases of activity known as the business cycle, which consists of four main stages: 1) expansion: This phase is characterized by increasing employment, income, industrial production, sales, and rising real GDP, 2) peak: The peak marks the highest point of an economic expansion, signifying a turning point in the cycle, 3) contraction: During this phase, the indicators of expansion begin to decline. If the decline is significant and spreads across the economy, it becomes a recession, 4) trough: The trough represents the lowest point of an economic contraction (Congressional Research Service, 2024). A complete business cycle is measured from peak to peak or trough to trough. These cycles typically vary in length and may include periods of contraction within an expansion, and vice versa (Kunal, S., 2024), (Congressional Research Service, 2024).

There are four key areas to foster economic growth (U.S. Library of Congress, 2024). Which are composed of 1) increase in physical capital goods which enhanced the quantity of physical capital goods in the economy boosts labor productivity with newer and improved tools, workers can produce more output within a given timeframe (Kunal, S., 2024), 2) improvements in technology by advancements in technology enable workers to achieve greater output using the existing stock of capital goods, as they can be combined in more efficient ways. The pace of technical growth is closely tied to rates of savings and investment, which are essential for funding research and development efforts, 3) growth of the labor force for expanding the labor force contributes to economic growth by increasing the production of goods and services.

However, it's important that the productivity of new workers offsets the additional consumption required to sustain them. Additionally, it's crucial for workers to be matched with suitable jobs and for complementary capital goods to be available to realize their full productive potential, 4) increasing human capital (Kunal, S., 2024), This involves enhancing the skills and capabilities of workers, leading to higher productivity through various means such as skills training, learning through trial and error, or gaining more experience in their respective fields. Savings, investment, and specialization are effective and manageable approaches to achieve this goal.

Moreover, human capital encompasses not only individual skills but also social and institutional aspects. Factors such as higher levels of social trust, reciprocity, and innovations in political or economic systems—such as enhanced protections for property rights—contribute to human capital and can significantly boost the overall productivity of the economy. By investing in human capital development, societies can improve workforce efficiency, foster innovation, and drive sustained economic growth (Kunal, S., 2024), (U.S. Library of Congress, 2024).

These four areas, when properly addressed and coordinated, can drive sustained economic growth by bolstering productivity and expanding output.

As pointed out by Kunal, S. (2024). In basic terms, economic growth entails making more resources available to more individuals, which is why governments prioritize its generation. However, it's not solely about monetary wealth, goods, and services; politics play

a crucial role. How economic growth is leveraged to drive social advancement holds significance.

Research from the United Nations University World Institute for Development Economics Research (Kunal, S., 2024). Indicates that most countries that have successfully reduced poverty and improved access to public goods have done so on the foundation of robust economic growth. Nevertheless, the institute underscores that for growth to be sustainable, its benefits must extend beyond just an elite segment of society.

DATA AND METHODOLOGY

DATA

The monthly time-series data were collected from the Bank of Thailand and Ministry of Digital Economy and Society from 2014 to 2023 with 120 observations.

METHODOLOGY

The econometric model applysing multiple regression was established for data analysis to calculate the impact of digital investment on income, employment and economic growth. The multiple regression was expressed as follow:

$$Dinvest_t = \beta_0 + \beta_1 * Income_t + \beta_2 * Employment_t + \beta_3 * EconGrt_t + e$$

Where:

$Dinvest_t$ stands for the digital investment at time t
$Income_t$ stands for the national income at time t
$Employment_t$ stands for the employment at time t
$EconGrt_t$ stands for the economic growth at time t

$$Dinvest_t = 0.0065 + 0.069 * Income_t + 0.603 * Employment_t + 0.260 * EconGrt_t + e$$

RESULTS AND DISCUSSION

Table1 – The impact of digital investment on income, employment and economic growth

Dependent Variable: Digital Investment

Variables	Coefficients	T-value
Income	0.069	67.725***
Employment	0.603	59.672***
Economic Growth	0.260	45.712***
R^2	0.826	
F	142.357	

******* exhibited the statisycal significance at 99 percent

The multiple regression was expressed as the follow:

$Dinvest_t = 0.0065 + 0.069 * Income_t + 0.603 * Employment_t + 0.260 * EconGrt_t + e$ – (1)

According to table 1 and equation 1, the impact of digital investment on imcome, employement and economic growth could be expressed as follow: an increase in digital business investment by 1 percent, then it will lead to an increasing in income by 0.069 percent. In addition, an increase in digital business investment by 1 percent will lead to an increase in

employment, and economic growth by 0.603 and 0.260 percent respectively. Digital business encompasses the integration of digital technologies to innovate and enhance various aspects of business operations.

The empirical research results expressed that digital investment in Thai economy has obviously impact directly on the national income in Thai economy. The digital investment play the key role in Thai economy as the economic driver as the source of income and employment. Digital investment also took its function as the one of the sources of economic growth.

The research results were consistent with the work of Bangzheng Wu & Weiguo Yang (2022). Who conducted their research on empirical test of the impact of the digital economy on China's employment structure. The research results were also consistent with the research work of Lin, H., Zhang, Z. (2023) who conducted their research on the impacts of digital finance development on household income, consumption, and financial asset holding: an extreme value analysis of China's microdata.

CONCLUSION

The research outcome obviously expressed the digital investment played the key role in Thai economy as the generator of income, employment and economic growth. Digital investment is reshaping income generation and employment by increasing access to markets, encouraging entrepreneurship, and enhancing financial education. The growth of fintech and associated technologies has created new career opportunities and offered innovative ways for individuals to boost their economic well-being.

Digital investment plays a crucial role in boosting income and employment through several channels, primarily by democratizing access to financial markets, fostering entrepreneurship, and supporting innovation as follow: 1) increased access to investment opportunities. Democratization of Investing expressed digital platforms allowing individuals with minimal capital to invest in stocks, bonds, cryptocurrencies, and other assets. This provides opportunities for individuals to grow their wealth and generate passive income. Digital investment generated global access, individuals from different parts of the world can now access international markets without significant barriers, creating new income streams that were previously inaccessible. The rise of digital investment platforms creates demand for developers, data analysts, cybersecurity experts, financial advisors, and other professionals, directly increasing employment opportunities. Digital investment platforms often provide educational resources, helping individuals understand financial markets, which can lead to smarter investments and better wealth-building strategies.

REFERENCES

Central Intelligence Agency. (2024). Central Intelligence Agency 2024 Chief Freedom of Information Act (FOIA) Officer's Report. https://www.cia.gov/readingroom/docs/CIA

International Monetary Fund. (2024). QUARTERLY REPORT June 30, 2024 https://www.fmimgt.com/international-fund

The Office of the National Economic and Social Development Council. (2024) Macroeconomic Planning. https://www.nesdc.go.th

World Bank Group. (2024). World Development Report 2024. https://www.worldbank.org/en/publication/wdr2024

World Trade Organization. (2024). WTO Public Forum 2024 https://www.wto.org (www.bangkokpost.com/life/tech) (2024) Digital investment in Thailand

Bangzheng Wu & Weiguo Yang. (2022). Empirical test of the impact of the digital economy on China's employment structure. *Finance Research Letters*, 10(49), 145-256. https://doi.org/10.1016/j.frl.2022.103047

Basnett, Y., & Ritwika, S. (2013). *What do empirical studies say about economic growth and job creation in developing countries?*, Overseas Development Institute, London, England

Congressional Research Service. (2024). Introduction to U.S. Economy. Retrieved from https://sgp.fas.org/crs/misc/IF10411.pdf.

Digital Economy Promotion Agency of Thailand. (2024). Digital investment in Thailand https://www.depa.or.th/th/article-view/depa-vdo-53

Gartner, (2014). Navigate the Digital Landscape with Confidence. https://hy.digital/service/digital

Investopedia. (2024). What Is Economic Growth and How Is It Measured? Retrieved from https://www.investopedia.com/terms/e/economicgrowth.asp.

Investopedia. (2024). What Is Economic Growth and How Is It Measured? Retrieved from https://www.investopedia.com/terms/e/economicgrowth.asp.

Kunal, S. (2024). Why should I care about economic growth? The United Nations University World Institute for Development Economics Research. Retrieved from https://www.wider.unu.edu/publication/why-should-i-care-about-economic-growth

Lin, H., Zhang, Z. (2023). The impacts of digital finance development on household income, consumption, and financial asset holding: an extreme value analysis of China's microdata. *Pers Ubiquit Comput* 27, 1607–1627. https://doi.org/10.1007/s00779-022-01667-z

Linkedin.com. (2024). *What is a Digital job?* Retrieved from https://www.linkedin.com/pulse/what-digital-job-cantello-tayler-recruitment-uqrse.

McKendrick. (2020). What is digital business. https://www.futurelearn.com/info/courses/digital-transformation-e-commerce

Melamed, C., Hartwig, R., & Grant, U. (2011). *Jobs, growth and poverty: what do we know, what don't we know, and what should we know?* The Wayback Machine London: Overseas Development Institute.

Office of Small and Medium Enterprises Promotion. (2024). Thai Economy in Brief. https://en.sme.go.th/en/

Richard, A., Kerry, b., Travers, M., & Ruschena, L. (2017). WHS: *A Management Guide (the 4th ed).* Cengage Learning, Australia.

Ristau, R., A. (2010). *Introduction to Business.* Cengage Learning, Australia.

Stephen, D. & Scott, A. J., (1989). Predicting job performance: A comparison of expert opinion and research findings. *International Journal of Forecasting*, *5*(2): 187–94.

U.S. Library of Congress. (2024). U.S. History Primary Source Timeline. Retrieved from https://www.loc.gov/classroom-materials/united-states-history-primary-source-timeline/rise-of-industrial-america-1876-1900/overview

Statista.com. (2020). Strategy and business building for the data-driven economy. https://www.statista.com/

THE ROLE OF A TECHNICAL COLLEGE IN THE THAI DIGITAL ECONOMY DEVELOPMENT: FROM POLICY TO PRACTICES

Anucha Wittayakorn-Puripunpinyoo[A]

ABSTRACT

The digital economy is altering the educational requirements for leading a successful life with well-being. The research objective was to study the role of a technical college in the Thai digital economy development. The research was a qualitative research methodology. The total population was divided into 3 groups: 1) 60 administrative staff, 2) 120 teachers, and 3) 2,371 students. The purposive sampling technique was applied to determine the sample size. With the inclusion criteria of sampling, the individuals with knowledge or experience in working with the digital economy have their willingness to give the data. It turned out of the sample size of 1) 10 administrative staff, 2) 10 teachers, and 30 students. The interview form was exploited as a data collection tool. The data were analyzed by content analysis, systematization, and synthesis. The results showed that the role of a technical college in the Thai digital economy development could be expressed in 4 key takeaways 1) The education which comprised of improving the educational service quality, from the last decade, the technical college has adopted the financial technology for all financial activities such as the payment for registration fees, management of the college's budget, including revenue, expenses, and budgeting, integration of the world educational standards, dual or multiple education, 2) innovations which comprised of creating and development of the innovation, creativity the development, introduction of innovation, 3) science which composed of efficiency improving the scientific research, commercialization of scientific results, increasing the prestige of scientific profession, 4) infrastructure which composed of development of digital infrastructure and innovations, introduction of the newest elements of infrastructure.

Keywords: *Technical College, Digital Economy Development, Innovation*

INTRODUCTION

Thailand's Thailand 4.0 strategy aims to move the nation from a production-based economy reliant on traditional manufacturing and agriculture to one driven by innovation, creativity, and technology. Central to achieving this vision is the development of a skilled workforce capable of thriving in emerging industries such as robotics, automation, artificial intelligence (AI), and the Internet of Things (IoT) (Digital Economy Promotion Agency, 2022). Technical colleges are playing a pivotal role in this effort, providing vocational and technical education that aligns with the needs of the evolving digital economy. This research paper seeks

[A] *Ph.D, School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: puanucha@windowslive.com*

to analyze how technical colleges contribute to digital economy development in Thailand by examining government policies, curriculum design, and partnerships with the private sector.

Government Policies Supporting Technical Colleges in the Digital Economy, Thailand's government has laid out several policies and initiatives that support the development of the digital economy, emphasizing the need for a skilled workforce. Thailand 4.0, as a national strategy, explicitly aims to transition the economy to one based on advanced technologies and high-skilled labor (National Broadcasting and Telecommunications Commission, 2021). Integral to this transition are technical colleges, which focus on offering hands-on, practical training in fields aligned with the country's digital economy goals, such as information technology (IT), automation, and digital manufacturing. Digital Economy Promotion Agency (2022): As part of its mandate to drive Thailand's digital economy, DEPA works closely with technical colleges to create industry-relevant curricula, particularly in emerging areas such as cybersecurity, AI, and smart technologies (Digital Economy Promotion Agency, 2022).

Ministry of Digital Economy and Society (2020): MDES supports workforce development programs at technical colleges by facilitating partnerships with industries to ensure that graduates possess the necessary digital skills for high-tech employment (Ministry of Digital Economy and Society, 2020).These policy initiatives aim to foster a sustainable talent pipeline that feeds directly into Thailand's growing digital economy sectors, helping ensure that technical college graduates are prepared to meet the needs of the evolving job market.

Curriculum Development and Skill-Building in Technical Colleges, Technical colleges in Thailand are at the forefront of adapting curricula to meet the demands of the digital economy. Competency-based education is becoming increasingly common in these institutions, ensuring that students are trained in the specific skills required by industries, such as software development, data analysis, robotics, and digital marketing (PWC Thailand, 2021).Digital Infrastructure and IT Training: Many technical colleges are emphasizing information and communication technology (ICT) programs, with students receiving education in areas such as coding, software engineering, network security, and cloud computing. These fields are critical to the growth of Thailand's digital infrastructure and the broader digital economy (National Broadcasting and Telecommunications Commission, 2021).

Practical, Hands-On Training: The focus on applied learning means that students in technical colleges often engage in real-world projects and internships that give them hands-on experience with the latest technologies. This is crucial for ensuring that graduates are job-ready and able to contribute immediately to the economy. The incorporation of emerging technologies into the curriculum is essential to preparing students for the challenges of a rapidly digitizing economy. By aligning education with the demands of the labor market, technical colleges can create a workforce capable of driving innovation and maintaining Thailand's competitiveness in the global digital economy.

Industry Partnerships and Workforce Readiness, Collaborations between technical colleges and industries are essential for ensuring that graduates possess the skills needed by employers. Many technical colleges have established partnerships with private sector companies to provide students with real-world training and job placements after graduation. These partnerships include: 1) Apprenticeship Programs: Some technical colleges have partnered with companies to provide students with internships and apprenticeships, offering hands-on experience in digital manufacturing, automation, and IT services (Digital Economy Promotion Agency, 2022), 2) Smart Industry Collaboration: Programs like Smart Visa and Thailand Tech Startup Promotion allow technical colleges to work with tech startups and multinational companies, giving students exposure to cutting-edge technologies and entrepreneurship (PWC Thailand, 2021).

These collaborations benefit both students and industries, as companies gain access to a pool of well-trained talent, and students receive practical experience and career opportunities in the digital economy. Challenges and Opportunities, while technical colleges in Thailand are making strides in supporting the digital economy, several challenges remain. One of the major issues is the digital divide between urban and rural areas. Many rural technical colleges lack access to the advanced technologies and resources available in urban centers, which limits their ability to provide cutting-edge education (National Broadcasting and Telecommunications Commission, 2021). Addressing this gap will be crucial for ensuring that all regions of Thailand benefit from digital economy development.

However, opportunities abound for technical colleges to further enhance their role. With the rollout of 5G technology and increased government investment in digital infrastructure, technical colleges have the potential to expand their offerings in areas such as IoT, AI, and smart agriculture (Ministry of Digital Economy and Society, 2020). These fields are expected to be key drivers of economic growth in the coming years.

Technical colleges are playing a crucial role in the development of Thailand's digital economy. Through government support, curriculum innovation, and partnerships with industries, these institutions are equipping students with the skills needed to thrive in a digitalized workforce. However, to fully realize their potential, technical colleges must continue to evolve, addressing challenges like the digital divide and ensuring that their programs remain aligned with the rapidly changing technological landscape. By doing so, technical colleges will remain a vital engine of economic growth and innovation in Thailand.

The development of Thailand's digital economy is gaining momentum as the country transitions from traditional industries to more technology-driven sectors. The government's "Thailand 4.0" policy is at the forefront of this transformation, seeking to establish a knowledge-based economy driven by innovation, digital technologies, and human capital. Technical colleges play a pivotal role in preparing the workforce to meet the demands of this digital economy by equipping students with the necessary skills in digital literacy, data science, AI, and more (World Economic Forum, 2023).

The role of technical colleges in fostering digital economy growth in Thailand, examining the policies and practices that shape their contribution. Key areas of focus include the alignment of curriculum with industry needs, the impact of government policies, partnerships with the private sector, and the challenges technical colleges face in fully integrating into the digital economy framework (Digital Economy Promotion Agency, 2023). Government Policies Supporting Digital Economy Development, The development of Thailand's digital economy is largely shaped by the government's policies and strategic plans, such as the Thailand 4.0 initiative, which aims to drive innovation and increase the country's competitiveness. Central to this initiative is the Digital Economy Promotion Agency (DEPA), which has laid out plans for integrating digital technologies into various sectors, including education (Digital Economy Promotion Agency, 2023), (Thailand Board of Investment, 2022).

The Thailand Digital Economy and Society Development Plan (2023-2027) emphasizes the need for technical education systems to align with the digital economy's demands. Specifically, the plan outlines objectives for Technical and Vocational Education and Training (TVET) institutions, like technical colleges, to focus on building digital skills such as programming, AI, and data analytics. These policies ensure that technical education evolves to meet the current and future needs of Thailand's industries (Thailand Development Research Institute, 2022), (Digital Economy Promotion Agency, 2023).

Curriculum Alignment and Digital Skills Training, One of the key roles of technical colleges in the Thai digital economy is to provide students with job-ready digital skills. The integration of emerging technologies into curricula is a major focus, with technical colleges

offering programs in software development, cybersecurity, and data science. The International Telecommunication Union (ITU) highlights how Thailand's technical colleges are increasingly developing specialized courses that incorporate AI, blockchain, and IoT to cater to the growing needs of digital industries (Digital Economy Promotion Agency, 2023)

Technical colleges are not only aligning their curricula with domestic needs but also incorporating global standards in digital skills education. For instance, collaboration with tech giants such as Microsoft Thailand has resulted in the offering of certifications in cloud computing and AI technologies, which enhances students' employability in the global digital economy (Thailand Development Research Institute, 2022). Partnerships with the Private Sector, The involvement of the private sector is crucial for ensuring that the skills taught in technical colleges meet industry requirements. Partnerships between educational institutions and companies help bridge the skills gap, providing students with hands-on experience through internships, apprenticeships, and co-designed curricula. KPMG Thailand reports that such partnerships are vital for keeping technical education aligned with the rapid changes in digital industries, ensuring students graduate with skills that are immediately applicable in the workforce (KPMG Thailand, 2023), (Digital Economy Promotion Agency, 2023).For example, the Board of Investment (BOI) in Thailand has implemented policies encouraging foreign and local companies to partner with technical colleges to promote skills training in areas like AI, IoT, and automation. These initiatives have helped in creating a robust digital skills pipeline that is directly tied to the labor market's demands (Thailand Board of Investment, 2022).

Challenges in the Integration of Digital Education, while technical colleges have made significant strides in contributing to Thailand's digital economy, several challenges remain. One such issue is the urban-rural divide. Many technical colleges in rural areas face difficulties in accessing cutting-edge technologies and attracting skilled instructors to teach advanced digital skills. The Thailand Development Research Institute (TDRI) highlights this challenge, emphasizing that without proper infrastructure and resources, rural colleges may lag behind their urban counterparts in providing digital education (Thailand Development Research Institute, 2022).

Another challenge is the speed of technological change. As industries continue to innovate, technical colleges must continually update their curricula to keep pace. The World Economic Forum (WEF) stresses the importance of lifelong learning and continuous professional development for educators themselves, ensuring they are equipped to teach the latest technologies (World Economic Forum, 2023).

Opportunities for the Future, The future of technical colleges in Thailand's digital economy is promising, particularly with ongoing government support and increasing private sector collaboration. As the digital economy expands, there is a growing need for colleges to provide upskilling and reskilling opportunities not only for new students but also for the existing workforce. This focus on lifelong learning, as seen in initiatives led by companies like Microsoft Thailand, will be key in ensuring that Thailand's workforce remains competitive on a global scale (International Telecommunication Union, 2023).

Moreover, as Thailand 4.0 continues to evolve, there is significant potential for technical colleges to serve as innovation hubs, where students, educators, and industry professionals collaborate to drive technological advancement (The Economist Intelligence Unit, 2022). The Digital Economy Promotion Agency (DEPA) outlines future plans for establishing such hubs within technical education institutions, which will further integrate technical colleges into the digital economy ecosystem (Digital Economy Promotion Agency, 2023), (International Telecommunication Union, 2023)

The role of technical colleges in Thailand's digital economy development is increasingly important. Through curriculum reform, industry partnerships, and alignment with government

policies, these institutions are shaping the future workforce needed for the country's digital transformation (Microsoft Thailand, 2023). While challenges such as the urban-rural divide and the rapid pace of technological change persist, the opportunities for technical colleges to become key players in the digital economy are abundant. Continued collaboration between the public and private sectors, along with the implementation of forward-thinking policies, will ensure that technical colleges remain central to Thailand's digital future (McKinsey & Company, 2022).

LITERATURE REVIEW

1. Technical College

A technical college is an educational institution that focuses on providing specialized training and education in technical fields, typically related to industries such as engineering, information technology, healthcare, manufacturing, and applied sciences. Unlike traditional four-year universities, technical colleges offer more practical, hands-on training, often in the form of two-year associate degrees, diplomas, or certificates, with a focus on preparing students for specific careers (American Association of Community Colleges, 2020).

Key Features of a Technical College: 1) Career-Oriented Education: Technical colleges prioritize teaching skills that directly translate into the workforce, ensuring that students are job-ready upon graduation. Many programs are designed to meet the needs of local industries (National Center for Education Statistics, 2021). 2) Shorter Program Duration: Compared to traditional universities, technical colleges typically offer shorter programs, ranging from a few months to two years. This allows students to enter the workforce more quickly (American Association of Community Colleges, 2020).3) Hands-On Training: Many technical programs emphasize practical, real-world skills through internships, lab work, and apprenticeships, enabling students to gain valuable experience before graduating (American Association of Community Colleges, 2020). 4) Industry-Relevant Curriculum: The curriculum is often designed in collaboration with industry leaders to ensure that students are trained in the most current technologies and methodologies required by employers in technical fields (National Center for Education Statistics, 2021).

Examples of Fields Offered at Technical Colleges (American Association of Community Colleges, 2020): 1) Engineering Technologies: Courses in mechanical, electrical, or civil engineering that prepare students for roles such as technicians or engineers (National Center for Education Statistics, 2021), 2) Information Technology: Programs that offer certifications in areas like network administration, cybersecurity, or software development (National Center for Education Statistics, 2021), 3) Healthcare: Training for medical support roles such as nursing assistants, radiologic technologists, or dental hygienists (American Association of Community Colleges, 2020).

Benefits of Attending a Technical College (National Center for Education Statistics, 2021). Affordability: Technical colleges generally offer lower tuition compared to four-year universities, making higher education more accessible (American Association of Community Colleges, 2020). Job Placement Support: Many technical colleges have strong connections with local industries and often provide job placement services for graduates (National Center for Education Statistics, 2021).Flexibility: Many programs offer flexible schedules, including evening and online classes, which cater to working adults or students with other commitments (American Association of Community Colleges, 2020).

2. Thailand’s digital economy development

Thailand’s digital economy development has been a key driver of its economic transformation, focusing on technology, innovation, and digital infrastructure. The Thai government, through its Thailand 4.0 initiative, is aiming to shift the country from a manufacturing and agriculture-based economy to one that thrives on digital technologies, automation, and innovation. Key components of this strategy include the development of digital infrastructure, support for startups and SMEs, and the growth of e-commerce and fintech.

Key Components of Thailand's Digital Economy Development: 1)Thailand 4.0 Policy: The Thailand 4.0 strategy represents the country's national plan to transition into a high-tech economy, focusing on industries like robotics, smart electronics, and digital technology. This policy underscores the importance of fostering innovation and expanding the digital sector to enhance economic productivity (Digital Economy Promotion Agency, 2023), 2) Digital Infrastructure Development: Thailand has made significant investments in its digital infrastructure, particularly in expanding broadband access and rolling out 5G technology. The National Broadcasting and Telecommunications Commission (2021) has played a central role in deploying 5G networks, making Thailand one of the first countries in Southeast Asia to embrace this technology. This development is expected to boost sectors such as smart manufacturing, agriculture tech, and health tech. 3) Support for Startups and SMEs: Through agencies like the Digital Economy Promotion Agency (2023), the Thai government is actively promoting digital innovation. DEPA has implemented initiatives such as grants, training programs, and networking events to support digital startups and small businesses.

Additionally, the introduction of incentives like Smart Visa has attracted foreign talent in the digital economy (Digital Economy Promotion Agency, 2023). 4) E-commerce and Fintech Growth: Thailand has seen rapid growth in its e-commerce and fintech sectors. The expansion of digital payment systems and improvements in logistics infrastructure have helped propel Thailand to become one of Southeast Asia’s largest e-commerce markets. The government has also created the Thailand Fintech Regulatory Sandbox, allowing for the testing of new financial technologies. 5) Digital Literacy and Workforce Development: To support its growing digital economy, Thailand has implemented digital literacy programs aimed at preparing its workforce with the necessary skills. Collaboration with the private and academic sectors is key to training workers in areas such as AI, coding, and cybersecurity.

While Thailand has made considerable progress, challenges such as the digital divide between urban and rural areas remain. Furthermore, ensuring data privacy and security has become a pressing issue as the digital economy expands, prompting the introduction of the Personal Data Protection Act.

3. Digital Policy of Thai Technical Colleges

As Thailand transitions into a digital economy under the Thailand 4.0 vision, technical colleges play a key role in developing a skilled workforce capable of navigating the demands of digital industries. In response to the government's digital economy policies, technical colleges are evolving their curricula, infrastructure, and collaborations to align with national goals. The Digital Policy of Thai Technical Colleges focuses on equipping students with digital skills, promoting e-learning, and fostering collaboration between industries and educational institutions. This paper provides an overview of these policies and their implications, supported by contemporary references and insights.

The foundation of digital policy in Thai technical colleges is shaped by the broader Thailand 4.0 initiative, which emphasizes innovation, technology, and human capital as central to economic growth. As part of this initiative, the Thai government has implemented the

Thailand Digital Economy and Society Development Plan (2023-2027), which outlines strategies for embedding digital competencies in educational systems, including technical colleges.

The Digital Economy Promotion Agency (2023) has been instrumental in guiding the integration of digital technologies into the educational sector. Technical colleges are expected to produce graduates proficient in fields such as AI, robotics, data science, and cybersecurity, in line with DEPA's objectives. The government has also mandated the adoption of ICT (Information and Communication Technology) infrastructure across all technical colleges to support e-learning and digital literacy initiatives.

The digital policy emphasizes updating curricula in technical colleges to include comprehensive training in emerging technologies. According to the Ministry of Education (MOE), technical education institutions must continuously revise their programs to integrate coding, AI, blockchain, IoT, and cloud computing into their offerings. The government's Digital Thailand Framework promotes the integration of these technologies into education as essential skills for the digital economy.

The Office of the Vocational Education Commission (2022) has spearheaded initiatives to provide digital literacy and advanced ICT training in technical colleges. These efforts include partnerships with tech giants such as Google, Microsoft, and Cisco, which help technical colleges offer certification programs and skill development workshops focused on the digital economy (Vocational Education, 2022).

One of the key components of the digital policy for technical colleges is the promotion of e-learning and online education platforms. The National Digital Education Framework encourages the use of online learning tools, virtual classrooms, and digital resources to enhance access to education, particularly in remote areas. This policy was accelerated by the COVID-19 pandemic, which highlighted the need for resilient and flexible learning environments. As a result, technical colleges have adopted hybrid learning models that combine in-person instruction with digital platforms such as Google Classroom and Moodle (Vocational Education, 2022).

UNESCO Bangkok highlights Thailand's efforts to incorporate e-learning in technical education as part of its larger TVET (Technical and Vocational Education and Training) digital transformation plan. This policy aims to make education more accessible to a wider population, particularly in underserved regions, and to equip students with the digital skills necessary to thrive in the global digital economy (UNESCO Bangkok, 2023).

Collaboration with the private sector is a crucial part of Thailand's digital policy for technical colleges. The Board of Investment (BOI) has implemented incentives for companies to partner with educational institutions, including technical colleges, to foster industry-based training and internship programs. These collaborations ensure that students are trained in real-world settings and are up to date with the latest digital tools and platforms used in industries such as fintech, AI, and manufacturing.

The KPMG Thailand (2023) reported emphasizes the importance of such partnerships in bridging the skills gap between educational institutions and industry needs. Technical colleges benefit from partnerships with companies that provide resources, updated curricula, and hands-on experience in fields critical to Thailand's digital economy.

Despite progress, there are challenges to fully implementing digital policies in Thai technical colleges. One of the key issues is the digital divide between urban and rural areas. Many technical colleges in rural regions struggle with inadequate ICT infrastructure and limited access to high-speed internet, which hampers the adoption of digital tools for learning and teaching (Ministry of Education, 2022).

The Thailand Development Research Institute (2022) points out that without consistent investment in ICT infrastructure and teacher training, the gap between urban and rural technical colleges will continue to widen. Furthermore, the rapid pace of technological change presents a challenge in keeping curricula updated, as many technical colleges lack the resources to continuously revise programs or purchase new technologies (Board of Investment, 2022).

Looking forward, the Thailand 4.0 policy continues to guide the integration of digital technologies into the education system. There are opportunities for technical colleges to further expand their role in driving the digital economy through lifelong learning and upskilling initiatives. These programs are not only for students but also for the existing workforce seeking to enhance their digital skills.

The Digital Economy Promotion Agency (2023) plans to expand its support for digital education through grants, infrastructure development, and digital literacy programs targeting both students and educators. These policies aim to create a more resilient and adaptive educational system capable of meeting the demands of an evolving digital economy.

The digital policies governing Thai technical colleges are crucial to the country's success in the digital economy. By focusing on digital skills, fostering e-learning, and promoting industry partnerships, technical colleges are positioned to be key contributors to Thailand's future economic development. Despite challenges such as the digital divide and rapidly changing technologies, ongoing government support and private sector collaboration present significant opportunities for growth. Technical colleges must continue to adapt to meet the demands of the digital age, ensuring that students are prepared for future careers in digital industries (The Digital Economy Promotion Agency, 2023).

DATA AND METHODOLOGY

The research was a qualitative research methodology. The total population was divided into 3 groups: 1) 60 administrative staff, 2) 120 teachers, and 3) 2,371 students. The purposive sampling technique was applied to determine the sample size. With the inclusion criteria of sampling, the individuals with knowledge or experience in working with the digital economy have their willingness to give the data. It turned out of the sample size of 1) 10 administrative staff, 2) 10 teachers, and 30 students. The interview form was exploited as a data collection tool. The data were analyzed by content analysis, systematization, and synthesis.

RESULTS AND DISCUSSION

The results showed that the role of a technical college in the Thai digital economy development could be expressed in 4 key takeaways 1) The education which comprised of improving the educational service quality, from the last decade, the technical college has adopted the financial technology for all financial activities such as the payment for registration fees, management of the college's budget, including revenue, expenses, and budgeting, integration of the world educational standards, dual or multiple education, 2) innovations which comprised of creating and development of the innovation, creativity the development, introduction of innovation, 3) science which composed of efficiency improving the scientific research, commercialization of scientific results, increasing the prestige of scientific profession, 4) infrastructure which composed of development of digital infrastructure and innovations, introduction of the newest elements of infrastructure.

Digital Economy and function of technical college

Thailand's shift toward a digital economy is primarily driven by the Thailand 4.0 initiative, a strategic policy that focuses on fostering innovation, integrating technology, and promoting high-value industries. This initiative seeks to move the country away from traditional agricultural and manufacturing-based economies to more advanced, knowledge-based sectors. Complementing this is the Digital Economy and Society Development Plan (2018-2037), which outlines a long-term strategy for utilizing digital technologies to spur economic growth. It prioritizes areas like education, infrastructure, and industry development, ensuring that the nation's workforce and systems are ready for the digital future.

Technical colleges play a pivotal role by aligning their curricula with the national strategies. They offer specialized training programs in critical fields such as information technology (IT), data science, and automation, directly contributing to the development of a skilled workforce capable of meeting the needs of the digital economy. By preparing students with the digital and technical expertise required, technical colleges help ensure that Thailand remains competitive in a rapidly digitizing global marketplace.

Education Policy and Skill Development

The Thai government recognizes the importance of equipping the workforce with digital skills to meet its digital economy targets. The Education 4.0 policy, which complements the Thailand 4.0 initiative, focuses on integrating technology into educational curricula, including those offered at technical colleges. These policies are designed to bridge the divide between education and industry by fostering partnerships and strengthening vocational training in critical digital fields such as software development, cybersecurity, and digital marketing.

The Role of Technical Colleges in Thailand's Digital Economy

Training the Digital Workforce

Technical colleges in Thailand prioritize equipping students with the skills and expertise needed to succeed in a digital economy. By offering specialized programs in areas such as IT, mechatronics, and robotics, these institutions play a leading role in producing highly skilled graduates who can meet the evolving needs of the digital workforce. Many technical colleges have also integrated training in cutting-edge technologies like artificial intelligence (AI), blockchain, and cloud computing into their curricula, preparing students for careers in high-demand industries**.**

Industry Collaboration and Internships

Technical colleges frequently partner with industries to ensure their training programs meet current real-world needs. By collaborating with technology firms and digital enterprises, these institutions offer students practical experience through internships, apprenticeships, and joint projects. Such partnerships provide valuable hands-on experience and industry exposure, which are essential for preparing students for success in a fast-changing digital economy.

Practical Approaches in Technical Colleges

Integrating Digital Skills into Curricula

Many technical colleges in Thailand have incorporated digital literacy and specialized digital skills into their core curricula. Courses such as software development, network management, and cybersecurity are now essential elements of the technical education

provided. This focus on practical, hands-on learning ensures that students acquire not only theoretical knowledge but also the practical expertise needed to effectively use digital tools and techniques.

Embracing E-Learning and Digital Platforms

In response to the needs of the digital age, technical colleges have progressively embraced e-learning platforms and blended learning models to enhance their educational delivery. These platforms offer students flexible learning options and promote self-directed study. Through digital tools and online resources, students can access the latest content, obtain industry certifications, and engage in digital simulations, all of which are vital for preparing them for the digital workforce.

Challenges and Opportunities

Addressing Technological Disparities

Despite significant progress in adopting digital technologies, technical colleges still face challenges due to disparities in access to advanced infrastructure. Colleges in rural areas and those with limited funding often lack the technological resources necessary for comprehensive digital learning. Addressing these disparities is crucial to ensuring that all students, regardless of their location, can fully engage with and contribute to Thailand's digital economy.

Lifelong Learning and Upskilling

As technological advancements accelerate, continuous learning and upskilling have become essential for staying relevant in the workforce. Technical colleges are increasingly integrating lifelong learning opportunities into their programs, offering both upskilling and reskilling options. These initiatives are designed to support current students and professionals who need to adapt to the ever-evolving digital landscape.

CONCLUSION

Technical colleges play a crucial role in Thailand's digital economy, acting as a bridge between educational policies and industry needs. By developing innovative curricula, fostering industry partnerships, and utilizing digital learning platforms, these institutions are preparing the next generation of skilled workers essential for Thailand's shift to a digital economy. Nevertheless, challenges such as technological disparities and the ongoing need for upskilling must be tackled to fully leverage the potential of these colleges. By aligning their programs with national digital economy strategies, technical colleges are not only supporting Thailand's economic growth but also shaping the future of its workforce.

REFERENCES

Board of Investment (BOI). (2022). Investment Promotion Policies for Thailand's Digital Economy. Retrieved from https://www.boi.go.th.

Digital Economy Promotion Agency (DEPA). (2022). Thailand's Digital Economy Development. Retrieved from https://www.depa.or.th.

Digital Economy Promotion Agency (DEPA). (2023). Thailand Digital Economy and Society Development Plan (2023-2027). Retrieved from https://www.depa.or.th.

International Telecommunication Union (ITU). (2023). *Digital Skills for Jobs: Thailand Country Report*. Retrieved from https://www.itu.int.

KPMG Thailand. (2023). Accelerating Digital Transformation in Thailand's Technical Education. Retrieved from https://home.kpmg/th.

KPMG Thailand. (2023). *The Digital Economy in Thailand: Accelerating Growth through Innovation and Skills Development*. Retrieved from https://home.kpmg/th.

Lertpanya, S. (2021). Overcoming digital divides in Thailand's technical education sector. Education and Development Review, 11(3), 97-110.

McKinsey & Company. (2022). *Shaping the Future of Thailand's Digital Workforce*. Retrieved from https://www.mckinsey.com.

Microsoft Thailand. (2023). *Empowering Thailand's Digital Future: The Role of Education in Workforce Transformation*. Retrieved from https://www.microsoft.com.

Ministry of Digital Economy and Society (MDES). (2020). Thailand's National Digital Economy Master Plan. Retrieved from https://www.mdes.go.th.

Ministry of Education (MOE). (2022). Digital Thailand Framework: Integrating ICT in Education. Retrieved from https://www.moe.go.th.

National Broadcasting and Telecommunications Commission (NBTC). (2021). 5G and the Future of Thailand's Digital Infrastructure. Retrieved from https://www.nbtc.go.th.

National Economic and Social Development Board (NESDB). (2017). Thailand 4.0: A New Value-Based Economy. Bangkok: NESDB.

Office of the Higher Education Commission (OHEC). (2017). Education 4.0: Preparing for Thailand's Digital Transformation. Bangkok: OHEC.

Office of the Vocational Education Commission (OVEC). (2022). Digital Skills in Vocational Education: Policy and Implementation. Retrieved from https://www.vec.go.th.

Phattharatham, P., & Lertpratchya, A. (2020). Strengthening industry-academia collaboration in vocational education: A case study in Thailand. International Journal of Technology and Vocational Education, 2(1), 18-29.

PWC Thailand. (2021). The Future of E-commerce and Fintech in Thailand. Retrieved from https://www.pwc.com.

Srisuwan, P. (2021). Lifelong learning for digital transformation: The role of vocational institutions in Thailand. Journal of Educational Research and Development, 6(2), 145-156.

Supasorn, P., & Wannapiroon, P. (2021). Digital literacy development in vocational education: Practices in Thai technical colleges. Journal of Educational Innovation, 10(2), 112-128.

Thailand Board of Investment (BOI). (2022). *Investment Promotion Policies for Thailand's Digital Economy*. Retrieved from https://www.boi.go.th.

Thailand Development Research Institute (TDRI). (2022). Challenges in Digital Transformation of Thai Education. Retrieved from https://www.tdri.or.th.

Thailand Development Research Institute (TDRI). (2022). *Thailand's Future Workforce: Digital Skills and Technical Education*. Retrieved from https://www.tdri.or.th.

The Economist Intelligence Unit (EIU). (2022). *Digital Workforce Development in Thailand: Bridging the Skills Gap*. Retrieved from https://www.eiu.com.

UNESCO Bangkok. (2023). TVET and E-Learning in Southeast Asia: The Case of Thailand. Retrieved from https://bangkok.unesco.org.

Wichitwanna, S. (2019). The impact of vocational education on workforce readiness for Thailand's digital economy. Journal of Vocational Education and Training, 71(3), 341-360.

World Economic Forum (WEF). (2023). *Thailand's Digital Economy: Building a Future-Ready Workforce*. Retrieved from https://www.weforum.org.

ETHICAL APPLICATION OF AI IN BUSINESS RESEARCH IN HIGHER EDUCATION: A LITERATURE REVIEW

Anothai Ngamvichaikit[A]

ABSTRACT

The integration of Artificial Intelligence (AI) in business research within higher education has revolutionized the field, offering unprecedented opportunities for data analysis, decision-making, and predictive modeling. However, this technological advancement also raises critical ethical concerns, including issues of bias, transparency, accountability, and privacy. The primary objective of this literature review is to explore the ethical implications of AI in business research in higher education, identify the challenges posed by these technologies, and propose potential strategies for ethical AI implementation in academic settings. The review employs a systematic analysis of existing literature, drawing from a diverse range of sources within the fields of business, ethics, technology, and higher education. Key ethical issues are examined, including the potential for algorithmic bias, the need for transparency in AI-driven research processes, and the importance of ensuring data privacy and security in academic environments. The review also assesses current regulatory frameworks and best practices aimed at mitigating these ethical risks in educational institutions. Findings from the literature reveal a significant gap between the rapid adoption of AI technologies in business research within higher education and the development of comprehensive ethical guidelines for academic use. The results indicate that while AI has the potential to enhance research outcomes in universities, the absence of ethical oversight can lead to significant risks, including compromised research integrity and stakeholder trust in educational settings. In conclusion, this review underscores the urgent need for a robust ethical framework to guide the use of AI in business research within higher education. The findings suggest that interdisciplinary collaboration and proactive regulation are essential to harnessing the benefits of AI while safeguarding ethical standards in academic research. Future research should focus on developing actionable guidelines and fostering the development of ethical AI use in business research within higher education institutions.

Keywords: *Ethical AI, Business Research, Data Transparency*

[A] *School of Management Science, Sukhothai Thammathirat Open University, Thailand.*
Email: anothai.ne@gmail.com Orcid: https://orcid.org/0000-0001-6988-2716

INTRODUCTION

The rapid advancement of artificial intelligence (AI) has significantly transformed various sectors, with business research in higher education being one of the primary areas of application. AI technologies, such as machine learning (ML), natural language processing (NLP), and deep learning, are increasingly being integrated into academic business analytics, decision-making processes, and research methodologies. These innovations contribute enhanced accuracy, productivity, and efficiency in handling complex datasets, thus offering a competitive edge to educational institutions and researchers who adopt AI-driven research strategies (Zhang & Lu, 2021; Davenport & Ronanki, 2018). However, the adoption of AI in business research within higher education also raises important ethical concerns that need to be carefully considered.

Ethical issues in AI applications within academic settings primarily revolve around data privacy, bias, transparency, accountability, and the broader social impacts of AI-driven research outcomes (Li, 2024; Sargiotis, 2024). While AI can optimize research processes and produce insightful analytics in higher education, its sophisticated process—referred to as the "black-box" problem—can lead to outcomes that are difficult to elaborate or justify (Rai, 2020). This raises questions about the fairness, interpretability, and accountability of AI-driven decisions in academic business research contexts, where ethical AI gaps can affect significant educational, reputational, and societal consequences (Vlaeminck, 2023). As business researchers in higher education increasingly rely on AI technologies to conduct empirical studies, these ethical challenges become particularly salient, necessitating a comprehensive review of the existing literature on the subject.

Despite the growing body of research on AI ethics, there remains a gap in understanding how these ethical principles can be practically applied in the context of academic business research within higher education institutions. Most of the existing literature focuses either on the technical aspects of AI or on broader philosophical discussions of ethics, leaving a need for a more focused exploration of how ethical frameworks can be integrated into academic research practices (Bouhouita-Guermech et al., 2023). This literature review aims to bridge this gap by providing a systematic examination of the ethical considerations relevant to the AI utilization in business research in higher education. It seeks to explore the ethical implications of AI adoption in academic business research, review current frameworks addressing these concerns within educational settings, and highlight potential solutions for ensuring the responsible use of AI in this domain of higher education.

METHODOLOGY

To comprehensively explore the ethical applications of AI in business research within higher education, a systematic literature review was conducted. This approach allowed for a thorough examination of existing knowledge and identification of key themes and gaps in the current literature.

Search Strategy: Three major academic databases were utilized: Web of Science, Scopus, and EBSCO Business Source Complete. These databases were chosen for their comprehensive coverage of business, education, and technology research. The following search terms and combinations were used:

- ("artificial intelligence" OR "AI" OR "machine learning")
- AND ("ethics" OR "ethical" OR "responsible")
- AND ("business research" OR "business education")
- AND ("higher education" OR "university" OR "college")

Inclusion Criteria	Exclusion Criteria:
• Peer-reviewed journal articles, conference papers, and book chapters • Published between 2016 and 2024 • Written in English • Focused on ethical considerations of AI use in business research or education in higher education settings	• Publications not peer-reviewed • Published before 2016 • Not in English • Focus primarily on technical aspects of AI without substantial discussion of ethical implications • AI applications outside of business research/education contexts

Selection Process: The initial database search yielded 99 articles. After removing duplicates and outdated from inclusion criteria, 97 unique publications remained. A researcher and co-researcher independently screened titles and abstracts, resulting in 27 articles for full-text review. Following full-text assessment, 22 articles met all the inclusion criteria and were included in the final analysis. The total studies spanned various years, with a notable increase in publications from 2021 to 2024:

This distribution reflects the growing academic interest in AI ethics within higher education and business research, particularly in recent years. This trend demonstrates the increasing relevance of AI in shaping research practices and the corresponding ethical concerns.

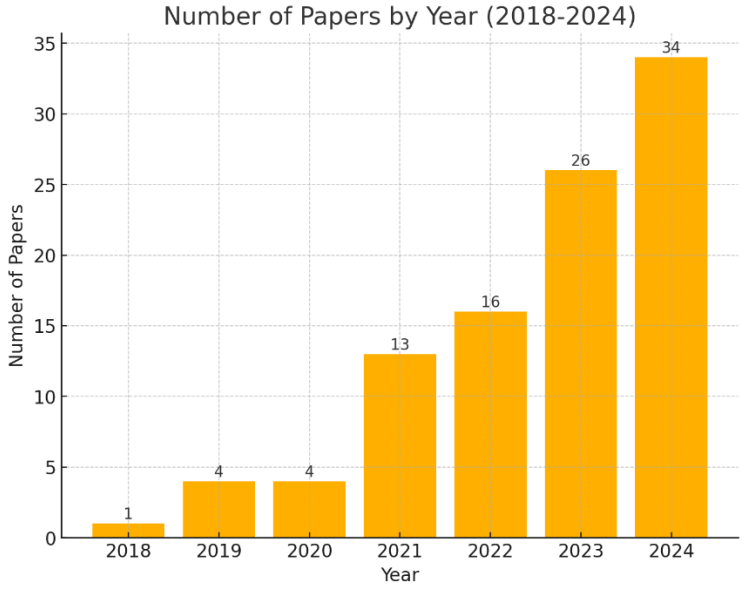


Figure 1 – Distribution of AI Ethics Studies by Year (2018-2024)

Data Extraction and Analysis: A standardized form was used to extract relevant data from each included article, including:

- Publication details (author, year, journal)
- Research design and methodology
- Key ethical issues addressed
- Proposed frameworks or guidelines
- Recommendations for practice

Thematic analysis was conducted using NVivo software to identify recurring themes and patterns across the literature. The analysis focused on:

1. Ethical challenges specific to AI in business research
2. Proposed ethical frameworks for AI use in higher education

3. Implications for research ethics boards and institutional policies
4. Gaps in current knowledge and areas for future research

Quality Assessment: The quality of included studies was assessed using the Critical Appraisal Skills Programme (CASP) checklist for qualitative research and the Joanna Briggs Institute (JBI) checklist for analytical cross-sectional studies. This assessment helped contextualize the strength of evidence supporting various findings and recommendations.

This systematic approach to the literature review ensures a comprehensive and rigorous examination of the current state of knowledge regarding ethical applications of AI in business research within higher education settings. The findings from this review will inform the development of guidelines and best practices for responsible AI use in academic business research.

RESULTS AND DISCUSSION

The analysis of the 22 selected studies still be ongoing, the initial results revealed a thematic focus on ethical issues concerning AI in business research within higher education. The findings are categorized into three themes, providing insights into the current state of AI ethics, as well as practical implications and opportunities for future exploration

1. AI-specific Ethical Guidelines in Business Research

The studies highlighted several significant ethical challenges. Key concerns regarding AI usage in academic business research include transparency, bias, and accountability. Many studies emphasized the need for clear guidelines to ensure fairness in AI algorithms (Castelló-Sirvent et al, 2024; Aler Tubella et al., 2024), noting that bias may persist, particularly when dealing with sensitive data. This issue is especially critical in academic environments where unbiased and equitable research outcomes are expected (Dabis & Csáki, 2024). In business research, technology innovation often be balanced with ethical responsibility, raising questions about how to balance the advantages of AI with its potential risks. The discussion underscores the importance of establishing clearer AI protocols and disseminatation toward academic stakeholders to address these ethical concerns in business research (Bond et al., 2024).

2. Proposed Ethical Frameworks for AI Use in Higher Education

Several studies proposed ethical frameworks to guide AI use in higher education and business research. These frameworks commonly stressed the importance of transparency in AI systems, obtaining informed consent from stakeholders, and maintaining accountability throughout the research process (Schiff, 2022). A key recommendation was to include AI ethics education in business and research program curricula, which would enhance researchers' understanding of ethical AI use and prepare future business leaders to consider the broader implications of AI technologies (Onyejegbu, 2023). However, the review noted that there is no universal solution, as the complexity of business research requires context-specific ethical guidelines tailored to various methodologies and AI applications.

3. Implications for Research Ethics Boards and Institutional Policies

The findings indicate that many higher education institutions lack comprehensive policies and guidelines for overseeing AI's ethical use in business research (Schultz, 2024). Existing institutional policies often fail to address the specific nuances of AI technologies, creating significant governance gaps. Research ethics boards were identified as needing

updated standards that address AI-driven research, such as participant data protection and AI system accountability (Dabis & Csáki, 2024). The discussion suggests that institutional leadership must actively develop AI governance structures to ensure that AI-related business research meets ethical standards and maintains academic integrity (Bond et al., 2024).

4. Current Knowledge Gaps and Future Research

Although literature on AI ethics in business research is growing (Daza & Ilozumba, 2022), substantial gaps of AI ethics in academic business research remain. Few studies offered concrete solutions to manage ethical challenges related to AI, and there is a lack of empirical research evaluating AI's long-term impact on research practices and outcomes (Zawacki-Richter et al., 2019). Ethical frameworks are often presented in broad terms without offering specific, actionable steps for implementation.

Future research should focus on developing and testing practical ethical frameworks for AI use in business research, particularly in higher education. Empirical studies are needed to explore how AI is influencing institutional policies and research ethics boards' oversight approaches. Addressing these gaps will contribute to a more comprehensive understanding of how to integrate AI responsibly into business research

CONCLUSION

The results of this review indicate the urgent need for ethical guidelines to keep up with the rapid growth of AI technologies in business research. Institutions and their ethics boards should collaborate to create policies that are both flexible and strict, ensuring AI's benefits in business research are used responsibly. Additionally, there is a clear call for more research to fill current knowledge gaps and create frameworks suited to the needs of business research in higher education.

REFERENCES

Aler Tubella, A., Mora-Cantallops, M., & Nieves, J. C. (2024). How to teach responsible AI in Higher Education: challenges and opportunities. *Ethics and Information Technology*, *26*(1), 3. https://doi.org/10.1007/s10676-023-09733-7

Al-Zahrani, A. M., & Alasmari, T. M. (2024). Exploring the impact of artificial intelligence on higher education: The dynamics of ethical, social, and educational implications. *Humanities and Social Sciences Communications*, *11*(1), 1-12. https://doi.org/10.1057/s41599-024-03432-4

Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., ... & Siemens, G. (2024). A meta systematic review of artificial intelligence in higher education: a call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, *21*(1), 4.Davenport, T. H., & Ronanki, R. (2018). Artificial intelligence for the real world. *Harvard business review*, *96*(1), 108-116. https://doi.org/10.1186/s41239-023-00436-z

Bouhouita-Guermech, S., Gogognon, P., & Bélisle-Pipon, J. C. (2023). Specific challenges posed by artificial intelligence in research ethics. *Frontiers in artificial intelligence*, *6*, 1149082. https://doi.org/10.3389/frai.2023.1149082

Castelló-Sirvent, F., Roger-Monzó, V., & Gouveia-Rodrigues, R. (2024). Quo Vadis, University? A Roadmap for AI and Ethics in Higher Education. *Electronic Journal of e-Learning*, *22*(6), 35-51. https://doi.org/10.34190/ejel.22.6.3267

Dabis, A., & Csáki, C. (2024). AI and ethics: Investigating the first policy responses of higher education institutions to the challenge of generative AI. *Humanities and Social Sciences Communications*, *11*(1), 1-13. https://doi.org/10.1057/s41599-024-03526-z

Daza, M. T., & Ilozumba, U. J. (2022). A survey of AI ethics in business literature: Maps and trends between 2000 and 2021. *Frontiers in Psychology*, *13*, 1042661. https://doi.org/10.3389/fpsyg.2022.1042661

Davenport, T. H., & Ronanki, R. (2018). Artificial intelligence for the real world. *Harvard business review*, *96*(1), 108-116.

Li, Z. (2024). Ethical frontiers in artificial intelligence: navigating the complexities of bias, privacy, and accountability. *International Journal of Engineering and Management Research*, *14*(3), 109-116.

Onyejegbu, L. N. (2023). Challenges of integrating AI ethics into higher education curricula in West Africa: Nigerian universities narrative. In *AI Ethics in Higher Education: Insights from Africa and Beyond* (pp. 57-66). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-23035-6_5

Rai, A. (2020). Explainable AI: From black box to glass box. *Journal of the Academy of Marketing Science*, *48*, 137-141. https://doi.org/10.1007/s11747-019-00710-5

Sargiotis, D. (2024). Ethical AI in Information Technology: Navigating Bias, Privacy, Transparency, and Accountability. *Adv Mach Lear Art Inte*, *5*(3), 01-14. https://doi.org/10.33140/AMLAI.05.03.03

Schiff, D. (2022). Education for AI, not AI for education: The role of education and ethics in national AI policy strategies. *International Journal of Artificial Intelligence in Education*, *32*(3), 527-563. https://doi.org/10.1007/s40593-021-00270-2

Schultz, M. D., & Seele, P. (2023). Towards AI ethics' institutionalization: knowledge bridges from business ethics to advance organizational AI ethics. *AI and Ethics*, *3*(1), 99-111. https://doi.org/10.1007/s43681-022-00150-y

Vlaeminck, E. (2023). Malicious Use of Artificial Intelligence and the Threats to Corporate Reputation in International Business. In *The Palgrave Handbook of Malicious Use of AI and Psychological Security* (pp. 273-293). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-22552-9_11

Zhang, C., & Lu, Y. (2021). Study on artificial intelligence: The state of the art and future prospects. *Journal of Industrial Information Integration*, *23*, 100224. https://doi.org/10.1016/j.jii.2021.100224

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators?. *International Journal of Educational Technology in Higher Education*, *16*(1), 1-27. https://doi.org/10.1186/s41239-019-0171-0

CEOS' FINANCIAL BACKGROUND AND ENTERPRISE DIGITAL TRANSFORMATION: EMPIRICAL EVIDENCE FROM CHINESE LISTED COMPANIES

Changchun Zhu[A], Li Zhang[B], Miaomiao Wang[C], Xiaobin Qi[D]

ABSTRACT

Enterprise digital transformation constitutes a management innovation within the context of the digital economy that necessitates substantial financial support, and CEOs with financial backgrounds significantly influence corporate financial investment strategies. This paper uses data from Chinese listed companies to explore the relationship between CEO financial background and enterprise digital transformation. The empirical findings suggest that (1) CEO financial background inhibits enterprise digital transformation. (2) R&D investment and management efficiency play partial mediating roles such that increasing R&D investment and enhancing management efficiency can mitigate some inhibitory effects and facilitate enterprise digital transformation. (3) Heterogeneity tests reveal that the inhibitory effect of CEO financial background is more pronounced for nonstate-owned enterprises, nonpolluting enterprises, and nondigital economic enterprises.

Keywords: *Enterprise Digital Transformation, CEO Financial Background, Listed Companies, R&D Investment, Management Efficiency*

1 INTRODUCTION

Vigorously developing the digital economy is a significant decision made by the 20th Congress of the Communist Party of China, and the rapid development of the digital economy is promoting the digital transformation of enterprises (Wei & Li, 2024). Digital finance is an integral part of the digital economy. Digital finance is the current financial stage through the digital transformation of the new financial industry. It is the inevitable result of financing in social, economic, and technological development trends. Some research results show that digital finance can significantly ease financing constraints and promote the digital transformation of enterprises and that the breadth of coverage and depth of use of digital finance enhance the digitalization of enterprises (G. Liu & Wang, 2023; Bu et al., 2024). Digital transformation has a profound effect on the financial industry, but in

[A] *PhD, Business School, Jiangsu Open University, Jiangsu, China. Email: zccnj@qq.com Orcid: https://orcid.org/0000-0003-4343-8638*

[B] *PhD, Business School, Jiangsu Open University, Jiangsu, China. Email: 841346163@qq.com Orcid: https://orcid.org/0000-0001-6099-4922*

[C] *PhD, Business School, Jiangsu Open University, Jiangsu, China. Email: 66555@qq.com Orcid: https://orcid.org/0009-0003-6481-832X*

[D] *Master's degree, Business School, Jiangsu Open University, Jiangsu, China. Email: 8924594@qq.com Orcid: https://orcid.org/0009-0002-6632-7789*

nonfinancial industries, digital transformation may be limited by the financial boom. Du Yong (2017), by examining data from Chinese listed companies, reported that financialization leads to lower corporate innovation and reduced investment in physical capital; in particular, the performance of the central business of brick-and- mortar companies is expected to be negatively affected (Du, Y. et al., 2017). If an enterprise is overfinancialized, too much working capital is used to purchase financial products and make financial investments, which will inevitably affect the average production of the enterprise, and excessive financialization may crowd out continuous innovation (Xie et al., 2022). Hu Haifeng (2020) proposed that capital has a profit-seeking nature and that the management of capital has different impacts on enterprises. Moderate financialization can increase the productivity of enterprises, whereas excessive financialization hinders their productivity (Hu, H. F. et al., 2020) Financialization has a significant crowding-out effect on enterprise innovation inputs and outputs, and enterprise financialization inhibits innovation outputs by "crowding out" research and development (R&D) inputs (Wan, Liangyong et al., 2020; Shi, Xuezhi & Yang, Zhen, 2021).

Digital transformation is a type of management change that requires a large amount of financial support. If an enterprise is overly financialized, it will have a crowding-out effect on the funds to carry out digital transformation, affecting the regular advancement of digital transformation. The CEO, as a decision maker at the top management level of the enterprise and the leading manager of direct operational management, can coordinate and manage the internal and external resources of the enterprise. It is crucial for the success of an enterprise's digital transformation, significantly impacting its digital transformation. Many studies have investigated the impacts of CEOs' R&D background, academic experience, social capital, power, tenure, composite function, technical background, green experience, and network relationships on enterprise digital transformation. The main ideas are as follows: CEOs with high academic backgrounds and enterprise digital transformation significantly contribute to the company's investment in innovation and improve the company's investment efficiency by increasing management equity incentives (Chen, Deqiu & Zhang, Wenyu, 2023); CEOs' academic experience affects enterprise digital transformation by enhancing innovation capabilities, improving the quality of management decisions, and improving financial financing to influence enterprise digital transformation (Ding, Yifan et al., 2023); CEOs' social capital can boost enterprise digital transformation through increasing R&D investment and improving strategic flexibility (Wei, Y. J. et al., 2023); CEO power has a significant positive effect on enterprise digital transformation, human capital, R&D investment and product market competition, all of which positively moderate the relationship between CEO power and enterprise digital transformation (Yuan, Zeming et al., 2023); CEOs' composite functional background significantly enhances the degree of enterprise digital transformation (Mao, J. et al., 2022); newly appointed CEOs disclose more information about digital transformation but invest less in substantive transformation (Zhang et al., 2023); and analysis of CEO compensation data reveals that CEO competition for higher compensation in neighboring firms drives digitalization within the firm (Hua & Yu, 2023). The above analysis of the literature shows that different backgrounds of CEOs have different effects on the digital transformation of enterprises; if a background can promote R&D investment, it will have a positive effect on the digital transformation of enterprises, but CEOs with financial backgrounds follow the focus on financial investment. They, therefore, may hinder the digital transformation of enterprises. This paper selects data from Chinese listed companies from 2010--2022 to empirically test the impact of a CEO's financial background on enterprise digital transformation. The results indicate that having a CEO's financial background hinders the in-depth development

of enterprise digital transformation; R&D investment and management efficiency play a part in the mediating effect. CEOs with financial backgrounds reduce the hindrance to enterprise digital transformation by increasing R&D investment and improving management efficiency. In the digital transformation of enterprises that are not state owned, nonpolluting, or nondigital economies, CEOs with financial backgrounds play a significant role in hindering the digital transformation of enterprises. The hindering effect is significant.

The rest of the paper is designed as follows: Section 2 presents the literature review and research hypotheses. Section 3 describes the data sources and empirical model. Section 4 presents the preliminary empirical results, including descriptive statistics and main effects regression analysis. Section 5 presents the robustness test of the empirical results. Section 6 presents a mechanism of action test for the mediating variables. Section 7 presents further analysis, which focuses on heterogeneity analysis. The last section presents the conclusion.

2 LITERATURE ANALYSIS AND RESEARCH HYPOTHESES

2.1 Research on CEOs' financial background

There have been many in-depth studies on the impact of CEOs' financial background on business operations and management. Through a survey study of American companies between 2004 and 2013, researchers found that CEOs with financial backgrounds can increase the profitability of the company and reduce the company's expenses, such as auditing (Kalelkar & Khan, 2016), and that more executives with financial backgrounds lead to more significant investment in financial assets and less investment in fixed assets (B. Liu et al., 2020). Researchers have reported a significant negative relationship between the financial background of CEOs and the internal control of firms on the basis of an analysis of data from Iranian listed companies from 2007—2017 (Oradi et al., 2020) and on the basis of 120 Saudi Arabian listed companies listed on the Tadawul Stock Exchange from 2014--2017, it was found that employing CEOs with a degree in business administration, economics, finance or accounting companies with a degree in business administration, economics, finance, or accounting performed very well in terms of corporate performance (Ghardallou et al., 2020). Using a sample of listed manufacturing firms in China from 2014—2020, researchers found that CEOs' financial background significantly inhibited industrial AI transformation in manufacturing firms (Xu & Zhang, 2023a) and that CEOs with financial backgrounds utilized their expertise to engage in natural active surplus management, which had a positive effect on the risk of stock price crashes (Jiang et al., 2022). The effect of CEO financial experience on the moderating effect of the association between digital transformation and innovation performance (Xu & Zhang, 2023b). Since the publication of Professor Du Yong's article "CEO Financial Background and Financialization of Real Firms" in 2019, the financial background of CEOs has begun to be widely studied by Chinese scholars. For example, Wang Panna (2019) reported that CEOs' financial background is significantly and positively related to the level of corporate cash holdings. When the role of a company's internal and external governance mechanisms is weaker, it is easier to induce the behavior of CEOs with financial backgrounds to seek private benefits by increasing cash holdings (Wang, Panna & Xu, Botao, 2019). Zhou Jinpei (2020) reported that CEOs with financial backgrounds are more likely to increase the proportion of financial assets of the firm by increasing the firm's business risk (Zhou, Jinpei, 2020). Lin Ziang et al. (2021) reported

that CEOs with financial backgrounds can actively promote the value-added of corporate goodwill (Lin, Z. A. & Tao, X. H., 2021). CEOs' financial background has a significant negative effect on corporate innovation. CEOs with financial backgrounds mainly inhibit corporate innovation by increasing financial investment and decreasing real investment, suggesting that CEOs' financial backgrounds exacerbate corporations' "derealization to devirtualization" behavior. "Derealization to virtualization" (李刚 et al., 2021). Liu Li et al. (2022) reported that a CEO's financial background significantly negatively affects business credit financing and that appointing CEOs with financial backgrounds reduces business credit financing, mainly because CEOs with financial backgrounds generate overconfidence problems (Liu, L. et al., 2022). A CEO's financial background can lead to corporate overinvestment and thus reduce corporate investment efficiency. The negative effect of CEOs with banking backgrounds is more significant because they increase overconfidence and reduce corporate financing constraints.

2.2 Relationship between CEOs' financial background and enterprise digital transformation

One of the main reasons for digital transformation is the rapid generation of digital technology, which requires a large amount of capital investment for R&D investment and equipment renewal. Wu Fei et al. (2021) and others reported that fintech and digital finance significantly affect enterprise digital transformation (Wu, Fei et al., 2021). Tang Song et al. (2022) reported that easing financing constraints and increasing research investment can help fintech promote enterprise digital transformation (Tang, Song et al., 2022). Wang Hongming (2022) reported that, in addition to easing financing constraints and increasing R&D expenditures, digital finance can improve the business environment and increase risk-bearing capacity by improving the business environment and increasing risk-taking capacity to promote enterprise digital transformation (Wang, H. M. et al., 2022). Lina Zhang (2021) reported that supply chain finance significantly affects enterprise digital transformation (Zhang, Lina et al., 2021). Many studies have shown that finance can promote enterprise digital transformation. However, Huang Dayu et al. (2022), from the School of Economics and Management at Tsinghua University, reported, on the basis of data of Chinese listed enterprises from 2008—2019, that the financialization of enterprises adversely affects their financial behaviors, financing, inputs, and innovation outputs and inhibits their digital transformation (Huang, D. Y. et al., 2022). Ren Xiaoyi et al. (2022) from the Guangdong Institute of Finance also found by studying the data of listed companies that corporate financialization does not have a reservoir effect and cannot provide financial resources to guarantee digital transformation; instead, it broadly impedes the promotion of digital transformation through the investment behavior of corporate entities (Ren, Xiaoyi et al., 2022). There are many new validations, such as CEO financial background, which significantly increases the proportion of financial assets of real enterprises; managerial ability, which plays a significant positive role between CEO financial background and asset financialization; and the stronger the ability of enterprise managers is, the more it helps CEOs with a financial background improve their decision- making regarding the degree of financialization of enterprise assets (Chang, Yunyi et al., 2022). A literature comparison shows that a CEO's financial background promotes corporate financialization, whereas corporate financialization hinders enterprise digital transformation; thus, research hypothesis 1 is proposed.

Hypothesis 1: CEOs' financial background hinders enterprise digital transformation.

3 RESEARCH DESIGN

3.1 Sample selection and data sources

The original data of this paper come from the China Stock Market and Accounting Research Database (CSMAR). In the process of sample screening, the data are processed as follows: first, firms with missing data in the missing part of the study period are excluded; second, listed firms in the financial category are excluded; third, listed firms in the ST and other abnormal trading statuses during the study period are excluded; fourth, since the extreme value of the continuous data in the time of regression may yield abnormal results, affecting the accuracy of regression, the tails of these types of data are decreased by 1% and 99%, respectively. Finally, 12776 valid samples of 2816 companies are obtained.

3.2 Definition of variables

3.2.1 Explained variable: Enterprise digital transformation

Referring to the practices of scholars such as Wu Fei et al. (2021) (Wu, Fei et al., 2021; G. Liu & Wang, 2023), the ratio of the word frequency data of digital transformation in the annual reports of listed companies to the total number of words is used to indicate the digital transformation of enterprises (DT1). In our robustness analysis, we refer to the measurement methods used by scholars such as Qi Huaijin (2020) and Xiao Tusheng (2022) (Zhang, Yongshen et al., 2021; Qi, Huaijin et al., 2020; Xiao, Tusheng et al., 2022; Huang, D. Y. et al., 2021) and use the proportion of the digital technology-related portion of the year-end intangible asset breakdown items disclosed in the annual reports of listed companies as a proxy variable for enterprise digital transformation (DT2).

3.2.2 Explanatory variable: CEO financial background

Referring to the definition of CEO financial background by Du Yong et al. (2019), a CEO is considered to have a financial background if he or she has held positions in policy banks, commercial banks, investment banks, financial regulatory authorities, fund management companies, insurance companies, stock exchanges, securities firms, securities registration and settlement firms, futures firms, trust firms, investment management firms, or other financial institutions; the value of this variable (CEOFIN) is recorded as 1; otherwise, it is recorded as 0 (Du, Y. et al., 2019).

3.2.3 Control variables

This paper selects three control variables: CEO characteristics, firm characteristics, and firm quality. These variables include (1) CEO characteristics variables: CEO age (CEO_Age), CEO gender (CEO_Sex), CEO academic experience (CEO_Acadexp), and CEO overseas experience (CEO_Oversea); (2) corporate governance variables: whether the CEO also serves as the chairperson of the board of directors (Both), the size of the board of directors (Board), the proportion of executive ownership (SR), the proportion of executive remuneration (SR), the proportion of executive remuneration (SR), and the proportion of executive remuneration (SR). Ratio (SR), executive compensation incentives (Payment3); (3) firm characteristics variables: firm age (Enterp_Age), nature of property rights (State), firm size (Size), gearing ratio (LEV), profitability (GP), net profitability of total assets (ROA), asset structure (AS), corporate sustainability (Growth), and industry growth (Ind_Q).

The specific definitions and measures of the variables, such as the explanatory, interpreted, and control variables, are shown in Table 1.

Table 1 – Description of variables

Variable Name	Symbols	Definition of variables
Enterprise Digital Transformation 1	DT1	Frequency/total number of digitized words in annual reports of listed companies
Enterprise Digital Transformation 2	DT2	Percentage of digital economy-related content in intangible assets disclosed in annual reports of listed companies
CEO Financial Background	CEOFIN	CEOs with finance-related professional experience are recorded as 1. Otherwise, it is recorded as 0
CEO Age	CEO_Age	Measured by the actual age of the CEO
CEO Gender	CEO_Sex	1 if the CEO's gender is male, 0 otherwise
CEO Overseas Experience	CEO_Oversea	1 if the CEO has overseas experience, 0 otherwise
CEO academic experience	CEO_Acadexp	1 if the CEO has academic experience, 0 otherwise
Whether the CEO is also the chairperson of the board	Both	Mark 1 if the CEO is also the chairperson of the board of directors; otherwise, mark 0
Size of Board of Directors	Board	Ln (1 + number of board members)
Executive Shareholding Ratio	SR	Executive shareholding as a percentage of total shares
Executive Compensation Incentive	Payment3	The sum of the top three highest-paid executives' pay/sum of all executives' pay
Age of the company	Enterp_Age	Present year minus the year the enterprise was founded
Nature of ownership	State	The nature of ownership is state-owned, which is recorded as 1. Otherwise, it is recorded as 0
Enterprise Size	Size	ln (total assets)
Gearing ratio	LEV	Total liabilities/total assets
Profitability	GP	Gross operating margin as a measure
Total Assets Net Profit Margin	ROA	Net profit/total assets
Asset Structure	AS	Total current assets/total assets
Industry Growth	Ind_Q	Median Tobin's Q for each industry for the year
Corporate Sustainability	Growth	Tobin's Q as a measure, Tobin's Q = Market Capitalization/Total Assets

3.2.4 Empirical model

To verify the proposed research hypotheses, regression model (1) is constructed on the basis of the data and variables screened in this paper:

$$DT_{it} = \alpha_0 + \alpha_1 CEOFIN_{it} + \alpha Controls_{it} + \sum Industryfe + \sum Yearfe + \varepsilon_{it} \quad (1)$$

In the model, the subscript denotes the variables for firm i in year t. Controls denotes the control variables used in this paper, Industryfe denotes the industry fixed effects controlled, Yearfe denotes the year fixed effects controlled, ε_{it} is the random disturbance term, α_0 denotes the intercept term, and α_1 is the explanatory variable of the CEO's financial background (CEOFIN) parameters to be estimated. If $\alpha_1 < 0$ in the regression results and is significant at more than the 10% criterion, this validates the expectation of the research hypothesis that CE0 with a financial background is more inhibited for firms to implement digital transformation.

4 EMPIRICAL ANALYSIS

4.1 Descriptive statistics and correlation test

Table 2 reports the descriptive statistics of the main variables used in this study. The data in this report indicate that the mean value of the degree of digital transformation (DT1) is 0.0097, and the standard deviation is 0.0092 during the period of 2010--2020; these data are consistent with the data of the previous descriptive statistics. This shows some differences in the degree of digital transformation between different listed companies: the degree of digital transformation of enterprises is low, and there is high research value in improving the quality of the digital transformation of enterprises. The mean value of the proxy variable for digital transformation (DT2) is 0.108, and the standard deviation is 0.217, indicating that investment in digital transformation is relatively low and that there is a need for research on improving investment in digital transformation. The mean value of CEO financial background (CEOFIN) is 0.0455, indicating that 4.55% of the CEOs have a background in financial careers and that the number of CEOs engaged in financial careers is low. In terms of control variables, CEO age (CEO_Age), gender (CEO_Sex), CEO overseas experience (CEO_Oversea), (CEO_Acadexp), whether the CEO is also the chairperson of the board of directors (Both), age of the firm (Enterp_Age), nature of the property rights (State), size of the firm (Size), the gearing ratio (LEV), profitability (GP), net profit margin on total assets (ROA), asset structure (AS), corporate sustainability (Growth), and industry growth (Ind_Q) are the same as in previous studies and will not be repeated here.

Table 2 – Descriptive Statistics

variable	N	mean	sd	min	p50	max
DT1	12776	0.0097	0.0092	0	0.0061	0.0478
DT2	12776	0.108	0.217	0	0.0253	1
CEOFIN	12776	0.0455	0.208	0	0	1
CEO Age	12776	49.53	6.440	32	50	66
CEO Sex	12776	0.937	0.242	0	1	1
CEO_Oversea	12776	0.0973	0.296	0	0	1
CEO Acadexp	12776	0.237	0.425	0	0	1
Board	12776	2.122	0.193	1.609	2.197	2.708
Both	12776	0.327	0.469	0	0	1
SR	12776	0.103	0.162	0	0.0112	0.644
Payment3	12776	0.444	0.119	0.209	0.431	0.816
Enterp Age	12776	16.21	5.662	2	16	33
State	12776	0.248	0.432	0	0	1
Size	12776	21.98	1.171	19.63	21.82	26.28
LEV	12776	0.374	0.189	0.0274	0.361	0.876
GP	12776	0.316	0.172	0.0166	0.284	0.860
ROA	12776	0.0522	0.0451	-0.298	0.0469	0.218
AS	12776	0.605	0.180	0.0838	0.617	0.966
Ind Q	12776	2.245	0.771	1.051	2.031	6.406
Growth	12776	2.756	1.942	0.785	2.155	17.01

Table 3 – Correlation coefficient test

	CEOFIN	DT1	DT2
CEOFIN	1.000	-0.008	-0.007
DT1	-0.008	1.000	0.456***
DT2	-0.013	0.427***	1.000

As shown in Table 3, by testing the correlation coefficients between the explanatory variables and the explanatory variables, the statistical tests of the Pearson and Spearman correlation coefficients between CEOFIN, DT1, and DT2 are also harmful. This result preliminarily verifies the primary hypothesis of this paper1, which suggests that CEOs with a financial background inhibit enterprise digital transformation. The next step is to control for more influencing factors and conduct multiple regressions to make the empirical results more rigorous.

In this work, we also conducted a multicollinearity test, an F test, a heteroskedasticity test, and a Hausman test on the data. The multicollinearity values are all less than 2, indicating that the model has almost no multicollinearity, and the F test result is 0<0.05; the fixed effect model is better than the random effect model. The heteroscedasticity test result was Prob>chi2=0, indicating the existence of heteroscedasticity between groups. The Hausman (overidentification) test was chosen to test for the presence of heteroscedasticity. The test result was P<0.05, indicating that fixed effects were superior to random effects.

4.2 Main effects regression analysis

The regression analysis between the CEO's financial background and enterprise digital transformation is conducted first. Table 4 shows the empirical results of testing Model (1) from multiple perspectives. Column (1) does not add control variables, and the results show that the estimated coefficient of CEOFIN is negative but not significant. Columns (2), (3), (4), and (5) present the empirical process of adding CEO characteristics variables, corporate governance variables, and firm characteristics variables, respectively, and the estimated coefficients of CEOFIN are still negative; however, the addition of these variables becomes significant at the 1% level, which fully confirms that in the actual process of enterprise operation, under the influence of multiple factors, the CEO's financial background inhibits the development of enterprise digital transformation.

Table 4 – Main effect test: CEO financial background and enterprise digital transformation

	(1) DT1	(2) DT1	(3) DT1	(4) DT1	(5) DT1
CEOFIN	-0.0004	-0.0010***	-0.0011***	-0.0008***	-0.0009***
	(-0.9422)	(-3.2191)	(-3.4368)	(-2.6662)	(-2.9354)
CEO_Age		-0.0000***	-0.0000***		-0.0000**
		(-2.8089)	(-3.0971)		(-2.4117)
CEO_Sex		-0.0005*	-0.0005*		-0.0004
		(-1.8963)	(-1.7762)		(-1.6246)
CEO_Oversea		0.0008***	0.0008***		0.0007***
		(3.3881)	(3.2643)		(3.0606)
CEO_Acadexp		0.0006***	0.0004**		0.0003**
		(3.7170)	(2.3814)		(2.0092)
Board			-0.0007**		-0.0005
			(-2.0247)		(-1.4302)
Both			0.0003		0.0002
			(1.6318)		(1.4086)
SR			0.0015***		0.0003
			(3.1058)		(0.6908)
Payment3			-0.0005		-0.0004
			(-0.7831)		(-0.6550)
Enterp_Age				-0.0000*	-0.0000
				(-1.7359)	(-1.3282)
State				-0.0006***	-0.0004**
				(-4.0604)	(-2.5109)

Size				0.0004***	0.0005***
				(5.8278)	(5.9726)
LEV				-0.0015***	-0.0014***
				(-3.1380)	(-3.0521)
GP				0.0013***	0.0012**
				(2.7378)	(2.4704)
ROA				-0.0091***	-0.0086***
				(-4.8773)	(-4.6581)
AS				0.0063***	0.0062***
				(14.9171)	(14.7665)
Growth				0.0002***	0.0002***
				(4.1335)	(3.8018)
Ind_Q				0.0000	0.0000
				(0.1148)	(0.1624)
_cons	0.0097***	0.0009	0.0027**	-0.0144***	-0.0124***
	(116.0662)	(1.3623)	(2.5453)	(-7.6822)	(-5.9307)
Industry	No	Yes	Yes	Yes	Yes Yes
Year	No	Yes	Yes	Yes	
N	12776	12776	12776	12776	12776
adj. R2	-0.000	0.393	0.394	0.406	0.408

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

Table 5 – CEOs with backgrounds in finance, business administration, law and enterprise digital transformation

	(1) **DT1**	**(2)** **DT1**	**(3)** **DT1**
CEOFIN	-0.0009***		
	(-2.9354)		
CEOmba		-0.0001	
		(-0.5187)	
CEOlawyer			-0.0005**
			(-2.1119)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	12776	12776	12776
adj. R2	0.408	0.407	0.407

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

Second, this paper analyzes CEOs with financial backgrounds in comparison to CEOs with business administrations and CEOs with legal backgrounds. According to the empirical report in Table 5, CEOs with business administration backgrounds and CEOs with legal backgrounds instead have a reverse influence effect on the process of enterprise digital transformation, hindering the process of enterprise digital transformation; in particular, CEOs with legal backgrounds are significantly pessimistic at the 5% level.

Compared with CEOs with business administration and legal backgrounds, CEOs with financial backgrounds have a more substantial reverse push effect on enterprise digital transformation.

5 ROBUSTNESS TESTS

5.1 Lagged explanatory and control variables

Although the main effects analysis proves that the CEO's financial background inhibits the development of firms' digital transformation, there may also be a reverse

causality endogeneity problem, i.e., the firms that positively exert the effect of the CEO's financial background may be the same ones that are reluctant to push forward the digital transformation firms. Column (1) of Table 6 results from regressing CEO financial background lagged one period (CEOFIN1), which is negative but insignificant. Column (2) is the result of regressing both the CEO's financial background and the control variables one period lagged, which is still negative but not significant enough. Although not significant enough, the structures are all negative and validate, to some extent, the inhibitory effect of a CEO's financial background on firms' willingness to undergo digital transformation.

Table 6 – Robustness test 1: lagged explanatory and control variables

	(1) **DT1**	**(2)** **DT1**
CEOFIN1	-0.0007	-0.0006
	(-1.6136)	(-1.4814)
Controls	Yes	No
Controls1	No	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	8363	8363
adj. R2	0.401	0.401

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

Table 7 – Robustness test 2: Propensity score matching method (PSM)

	(1) **DT1**	**(2)** **DT1**
CEOFIN1	-0.0008*	-0.0006
	(-1.7385)	(-1.4350)
Controls	No	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	1127	1127
adj. R2	0.352	0.371

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

5.2 Propensity score matching (PSM) method

In this paper, we continue to use the propensity score matching (PSM) method to test the endogeneity problem arising from biased sample selection. The main operational steps are consistent with those in the previous section and are not repeated here. Figures 1 and 2 show the results of the treatment and control groups before and after matching, respectively. The trends of the treatment and control groups after matching are relatively consistent, and the matching effect is good. Table 7 shows the sample regression results after matching. The estimated coefficient of CEOFIN is significantly negative at the 10% level without control variables and negative but not significant after adding control variables. The PSM test proves that the effect of sample selection bias is small and generally verifies the fitting effect of CEOs' financial background and the digital transformation of enterprises.

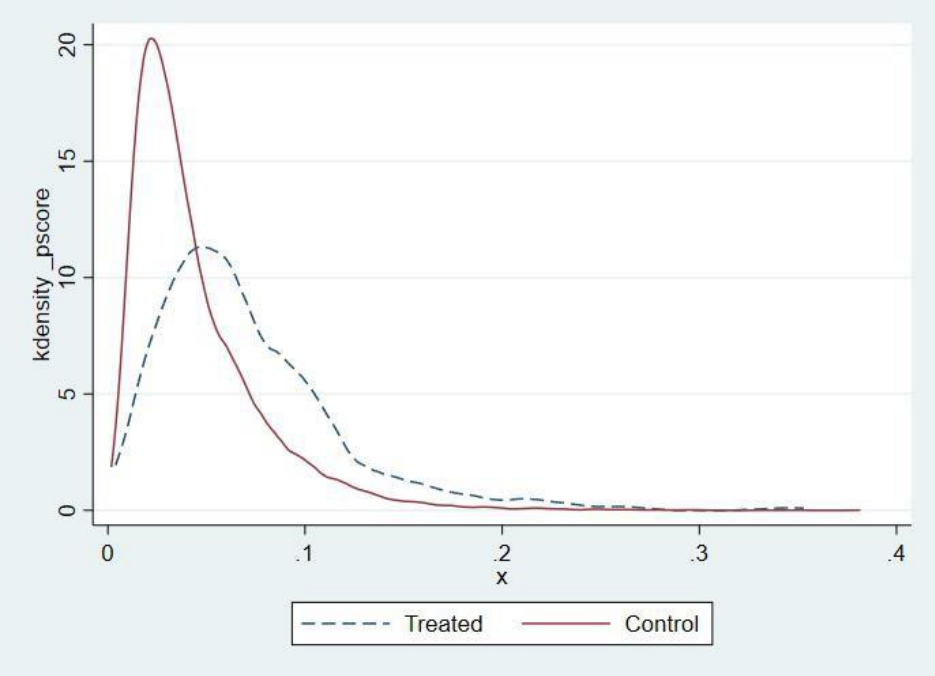


Figure 1 – Comparison between the pretreatment and control groups in terms of CEO financial background and enterprise digital transformation match

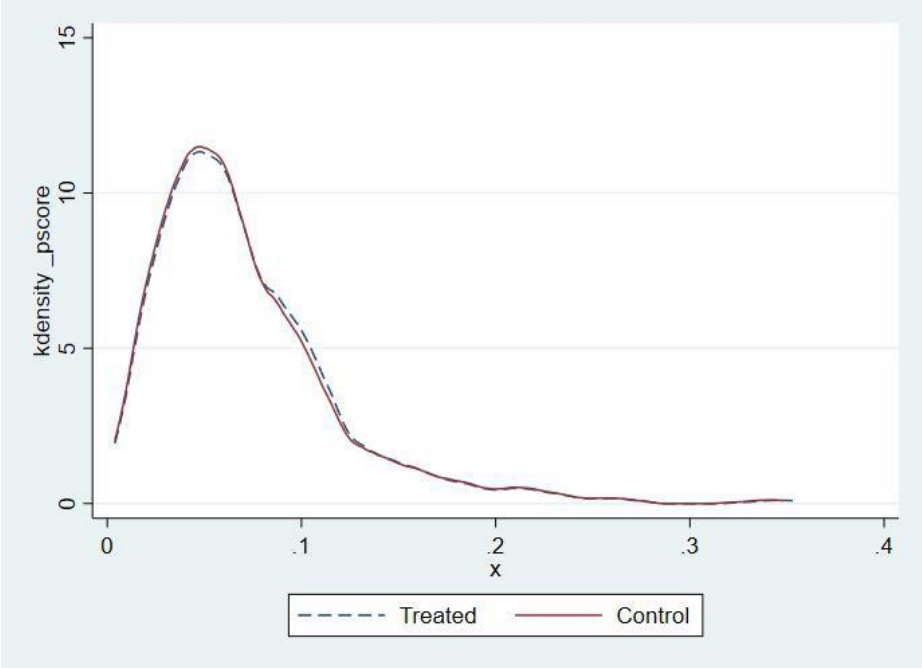


Figure 2 – Comparison of the treatment and control groups after matching in the study of CEO financial background and enterprise digital transformation

5.3 Replacement Variables

This paper uses the ratio of the digital economy-related portion of the year-end intangible asset breakdown items disclosed in the notes to the financial reports of listed companies to the total intangible assets as a replacement variable for the digital transformation of enterprises (DT2). Table 8 shows that the CEOFIN results for DT2 are the same as those for DT1 after separate regressions with different control variables. The regression that replaces the explanatory variables shows consistent results, thus indicating that the main regression effect is robust.

Table 8 – Robustness Test 3: Replacing Explained Variables

	(1) DT2	(2) DT2	(3) DT2	(4) DT2	(5) DT2
CEOFIN	-0.0132	-0.0250***	-0.0264***	-0.0188***	-0.0200***
	(-1.5603)	(-3.4863)	(-3.6196)	(-2.7031)	(-2.8079)
CEO_Age		-0.0005*	-0.0005*		-0.0003
		(-1.8778)	(-1.8803)		(-1.3207)
CEO_Sex		-0.0043	0.0009		0.0024
		(-0.6017)	(0.1214)		(0.3479)
CEO_Oversea		0.0228***	0.0204***		0.0199***
		(3.6847)	(3.3087)		(3.2791)
CEO_Acadexp		0.0023	-0.0040		-0.0064
		(0.5808)	(-0.9728)		(-1.5855)
Board			-0.0255***		-0.0095
			(-2.6198)		(-0.9760)
Both			0.0008		0.0016
			(0.1906)		(0.3624)
SR			0.0702***		0.0219
			(5.2281)		(1.6264)
Payment3			0.0513***		0.0376**
			(3.5037)		(2.5313)
Enterp_Age				-0.0006*	-0.0005
				(-1.7946)	(-1.6276)
State				0.0111***	0.0161***
				(2.7982)	(3.8042)
Size				-0.0081***	-0.0068***
				(-4.2718)	(-3.5520)
LEV				0.0202*	0.0222*
				(1.6993)	(1.8663)
GP				0.0561***	0.0569***
				(4.2921)	(4.3536)
ROA				-0.2264***	-0.2263***
				(-4.9117)	(-4.8965)
AS				0.1822***	0.1826***
				(16.3431)	(16.3863)
Growth				0.0097***	0.0092***
				(6.7952)	(6.4132)
Ind_Q				-0.0030	-0.0027
				(-0.2971)	(0.2670)
_cons	0.1090***	0.0557***	0.0796***	0.0390	0.0272
	(55.3445)	(2.9751)	(2.7209)	(0.7478)	(0.4740)
Industry	No	Yes	Yes	Yes	Yes
Year	No	Yes	Yes	Yes	Yes
N	12776	12776	12776	12776	12776
adj. R2	0.000	0.286	0.290	0.318	0.319

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

5.4 Changes in measures

In this paper, we use the truncated-tail regression, i.e., the Tobit model, for the robustness test of changing measures, which is validated by changing the OLS regression to a Tobit regression. The regression results in Table 9 show that the estimated coefficients of CEODT are significantly positive at the 1% level for Digital Transformation of Enterprises (DT1), indicating that the results of the main regression effect are robust.

Table 9 – Robustness Test 4: Changing Measures (tobit regression)

	(1) DT1	(2) DT1
DT1		
CEOFIN	-0.0010***	-0.0009***
	(-3.1258)	(-3.0916)
Controls	No	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	12776	12776

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

6. MECHANISM OF ACTION TEST

The primary effect calibration and robustness test confirm that CEOs' financial background significantly inhibits the degree of enterprise digital transformation. What is the primary mechanism of action that affects this inhibitory effect? This paper searches for reasons for R&D investment, management efficiency, capital management, sustainable development, environmental impact, and social responsibility. Through several experiments, the CEO's financial background affects enterprise digital transformation through R&D investment and management efficiency. The experiments also studied internal and external behaviors such as sustainable development and environmental impact. However, none of them had a significant effect on the relationship between the CEO's financial background and enterprise digital transformation.

6.1 Mediating effect of R&D input

R&D investment is measured via the ratio of R&D expenditures to operating revenues, and the data are obtained from the China Stock Market and Accounting Research Database (CSMAR) database. This section uses three models, model (1) and the newly constructed models (2) and (3), to demonstrate this path of action: Model (1) is used as a primary effect test for the effect of CEO financial background (CEOFIN), and if the coefficient is significant, Model (2) is used to test the effect of the explanatory variable (CEOFIN) on the mediator variable (RD); if the coefficient is significant, Model (3) is used to incorporate both the explanatory variable (CEOFIN) and the mediating variable (RD); if the coefficient ϕ_2 is significant and ϕ_1 is not significant, then it is a full mediation effect; however, if the coefficient ϕ_2 and the coefficient ϕ_1 are significant, then it is a partial mediation effect; if the coefficient ϕ_2 is not significant, then the mediation effect is not valid.

$$RD_{it} = \varphi_0 + \varphi_1 CEOFIN_{it} + \varphi Controls_{it} + \sum Industryfe + \sum Yearfe + \varepsilon_{it} \quad (2)$$

$$DT1_{it} = \phi_0 + \phi_1 CEOFIN_{it} + \phi_2 RD_{it} + \phi Controls_{it} + \sum Industryfe + \sum Yearfe + \varepsilon_{it} \quad (3)$$

The regression results are shown in Table 10. Column (1) shows the results confirmed in the previous section; i.e., the effect of CEO financial background (CEOFIN) on firms' digital transformation (DT1) is significantly negative at the 1% level. The estimated coefficient of CEOFIN in column (2) is -0.5530, which is significant at the 1% level, indicating that CEOs' financial background has a significant inhibitory effect on firms' research and development investment (RD); the estimated coefficient of RD in column (3) is significantly positive at the 1% level, and the estimated coefficient of CEOFIN is similarly significantly negative at the 5% level. However, the estimated coefficient of CEOFIN decreases, suggesting that R&D investment (RD) is a partial mediating effect between the CEO's financial background and the firm's digital transformation. The results of Sobel's test show that the Z statistic is equal to 4.028 and is significant at the 1% level, which verifies a partial mediating effect according to the results of the mediation effect test. Further calculations show that the mediating effect of research and development investment (RD) between the CEO's financial background and the firm's digital transformation is 30% of the total effect, calculated via the procedure (- 0.5530*0.0005)/-0.0009.

Table 10 – Mechanism test 1: R&D investment

	(1) DT1	(2) RD	(3) DT1
CEOFIN	-0.0009***	-0.5530***	-0.0007**
	(-2.9354)	(-4.3123)	(-2.2213)
RD			0.0005***
			(16.8007)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	12776	12776	12776
adj. R2	0.408	0.469	0.432

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

6.2 Mediating effects of managerial efficiency

CEOs' management ability and background characteristics profoundly affect the management efficiency of enterprises. Management efficiency is a critical way to improve the quality capability of Chinese enterprises. In contrast, product quality competitiveness and quality factor allocation status are two important channels through which management efficiency promotes upgrading quality capability (Li, Tang et al., 2018). The mixed ownership reform of state-owned enterprises improves the innovation sustainability of enterprises by improving their management efficiency (Xu, Chenxi et al., 2023). A high degree of market competition and high management shareholding can enhance the management efficiency of enterprises (Li, Jian et al., 2016), and the positive effect of service liberalization on the exports of enterprises with high management efficiency is more significant (Sun, Puyang et al., 2018). This part takes management efficiency (ME) as a mediating variable to study the impact of the CEO's financial background on enterprise digital transformation. For the measurement of management efficiency, this paper refers to the studies of Yang Jisheng and Yang Jianhui and Zeng Zhuoran et al. (Yang, Jisheng & Yang, Jianhui, 2015), which use the ratio of the sum of corporate overhead and selling expenses to total operating revenue to measure this indicator, and the larger the indicator value is, the lower the management efficiency of the enterprise (Zeng, Zhuoran et al., 2021). This part uses three models, model (1) and the newly constructed model (4)(5), to argue for this path of action: the testing process is the same as the research and development (RD) investment process and will not be repeated here.

$$ME_{it} = \mu_0 + \mu_1 CEOFIN_{it} + \mu Controls_{it} + \sum Industryfe + \sum Yearfe + \varepsilon_{it} \quad (4)$$

$$DT1_{it} = \nu_0 + \nu_1 CEOFIN_{it} + \nu_2 ME_{it} + \nu Controls_{it} + \sum Industryfe + \sum Yearfe + \varepsilon_{it} \quad (5)$$

The regression results are shown in Table 11. Column (1) presents the results confirmed in the previous section; the effect of CEOs' financial background (CEOFIN) on firms' digital transformation is significantly positive at the 1% level. The estimated coefficient of CEOFIN in column (2) is 0.3158 and is significantly positive at the 5% level, indicating that CEO financial background management can significantly improve the managerial efficiency of firms; the estimated coefficient of managerial efficiency (ME) in column (3) is negative and significant, and the estimated coefficient of CEOFIN is likewise significantly positive at the 1% level. However, the estimated coefficient of CEOFIN is small. According to the results of the mediation effect test, managerial efficiency (ME) is a partial mediator between the CEO's financial background and the firm's digital transformation. However, the mediation effect is small and does not account for a significant share of the total effect. Compared with R&D investment, the essential kinetic energy of enterprises to promote digital transformation is still technological innovation within the enterprise.

Table 11 – Mechanism Test 3: Managerial Efficiency

	(1) DT1	(2) ME	(3) DT1
CEOFIN	-0.0009***	0.3158**	-0.0009***
	(-2.9354)	(2.2705)	(-2.9096)
ME			-0.0000*
			(-1.6706)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	12776	12776	12776
adj. R2	0.408	0.041	0.408

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

7 FURTHER ANALYSIS

7.1 Heterogeneity of Property Rights Nature

To verify the nature of property rights on the relationship between the CEO's financial background and the firm's digital transformation, first, the nature of property rights (State) is cross-multiplied with the CEO's financial background (CEOFIN) before regression analysis. Column (4) of Table 12 shows the regression results, and the cross-multiplication term coefficient is positive but insignificant. Column (5) shows the regression results after centering the cross-multiplier term, which is consistent with the results before no centering. Second, the regression analysis is performed on cross-sectional data according to the nature of ownership, thus guaranteeing the robustness of the results, and columns (2) and (3) present the regression results. In the SOE group, the estimated coefficient of CEOFIN is 0.003 but insignificant; in the non-SOE group, the estimated coefficient of CEOFIN is -0.0012 and significant at the 1% level. The above testing process indicates that CEOs' financial background has a more substantial inhibitory effect on the digital transformation of nonstate-owned enterprises than on that of state-owned enterprises.

Table 12 – Heterogeneity analysis 1: Nature of property rights

	(1) all sample	(2) State=1	(3) State=0	(4) all sample	(5) centralization
CEOFIN	-0.0009***	0.0003	-0.0012***	-0.0011***	-0.0008**
	(-2.9354)	(0.3512)	(-3.4883)	(-3.3404)	(-2.4045)
State	-0.0004**			-0.0005***	-0.0004**
	(-2.5109)			(-2.7468)	(-2.3715)
CEOFIN×State				0.0014	
				(1.5488)	
c.c_CEOFIN#c.c_State					0.0014
					(1.5488)
Controls	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	12776	3175	9601	12776	12776
adj. R2	0.408	0.472	0.393	0.408	0.408

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

Table 13– Heterogeneity Analysis 2: Corporate Pollution

	(1) all sample	(2) HPollut=1	(3) HPollut=0	(4) all sample	(5) centralization
CEOFIN	-0.0009***	-0.0004	-0.0008*	-0.0007*	-0.0008**
	(-2.9354)	(-1.4813)	(-1.7459)	(-1.7237)	(-2.4989)
HPollut				-0.0031***	-0.0031***
				(-21.2976)	(-21.6918)
CEOFIN×HPollut				-0.0002	
				(-0.4318)	
c.c_CEOFIN#c.c_HPollut					-0.0002
					(-0.4318)
Controls	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	12776	3602	9174	12776	12776
adj. R2	0.408	0.185	0.385	0.421	0.421

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

7.2 Heterogeneity of firm pollution

Environmental regulations influence polluting firms, and they are more aware of digital transformation than nonpolluting firms are. The literature analysis of corporate pollution was conducted in the previous section and is directly verified here. To verify the role of the CEO's financial background in the digital transformation of polluting firms, first, corporate pollution (HPollut) is cross-multiplied with the CEO's financial background (CEOFIN), and column (4) of Table 13 shows the regression results with negative coefficients of cross-multiplied terms. Column (5) shows the regression results after centering the cross-multiplier term, which is consistent with the results before no centering. Second, cross-sectional data regressions are analyzed according to firm pollution, thus guaranteeing the robustness of the results, and columns (2) and (3) present the regression results. For the group of heavily polluting firms, the estimated coefficient of CEOFIN is -0.0004 but insignificant; for the group of nonheavily polluting firms, the estimated coefficient of CEOFIN is approximately -0.0008, which is significant at the 10% level. The above testing process indicates that for nonheavily polluted firms, the CEO's financial background has a more significant mimetic effect on firms' digital transformation; for

heavily polluted firms, the CEO's financial background has a mimetic effect on firms' digital transformation but is not significant.

7.3 Heterogeneity of the digital economy

Compared with nondigital economy firms, digital economy firms are affected by environmental regulation and have a more active sense of digital transformation. First, cross-multiplying whether or not they are heavy digital economy firms (DEconomy) with a CEO financial background (CEOFIN), column (4) of Table 14 shows the regression results; the coefficient of the cross-multiplication term is negative. Column (5) shows the regression results after centering the cross-multiplier term, which is consistent with the results before no centering. Second, cross-sectional data regressions are analyzed according to whether they are digital economy firms, thus guaranteeing the robustness of the results, and columns (2) and (3) present the regression results. For the group of digital economy firms, the estimated coefficient of CEOFIN is -0.0012, which is insignificant. In contrast, for the group of nondigital economy firms, the estimated coefficient of CEODT is approximately -0.0006, which is significant at the 10% level. For digital economy firms, the CEO's financial background has a mimetic effect on firms' digital transformation but is not significant; for nondigital economy firms, the CEO's financial background has a mimetic effect on firms' digital transformation, which is more significant.

Table 14 – Heterogeneity analysis 3: whether digital economy enterprises

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	all sample	**DEconomy=1**	**DEconomy=0**	**all sample**	**centralization**
CEOFIN	-0.0009***	-0.0012	-0.0006**	-0.0005**	-0.0009***
	(-2.9354)	(-1.4396)	(-2.2484)	(-1.9875)	(-2.9920)
DEconomy				0.0071***	0.0070***
				(30.3420)	(30.3272)
CEOFIN×DEconomy				-0.0014	
				(-1.5697)	
c.c_CEOFIN#c.c_DEconomy					-0.0014
					(-1.5697)
Controls	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	12776	3077	9699	12776	12776
adj. R2	0.408	0.308	0.222	0.466	0.466

Note: t values are in parentheses; *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.

8 RESEARCH CONCLUSIONS

8.1 Research findings

Many studies have reported that CEOs' financial background tends to cause excessive financialization of enterprises, which affects some of their production, construction, operation, and management inputs. By analyzing ten years of data from 2010--2022 for Chinese listed companies, this paper finds that CEOs' financial background has a specific inhibitory effect on the digital transformation of Chinese enterprises. This is also verified through a series of robustness tests. For the mechanism of action, all the relevant variables are validated. However, factors such as R&D investment and management efficiency have partial mediating effects; the size and significance of these effects are not

the same. R&D investment is the most significant variable that affects the digital transformation of enterprises; similar to the findings of other studies, the CEO's financial background influences enterprises to reduce R&D investment, which significantly increases the inhibitory effect on the digital transformation of enterprises. The mediating effect of R&D investment on the impact of the CEO's financial background on firms' digital transformation was calculated to be 30% of the total effect, which is significant. In terms of management efficiency, CEOs' financial background significantly and positively increases the management efficiency of enterprises. However, the mediating effect on enterprise digital transformation is small and does not account for a high percentage of the total effect. This paper also validates corporate social responsibility and media attention, but they are not significant enough. Further analysis revealed that there is some heterogeneity, such as in property rights, corporate pollution, and the digital economy, in terms of the impact of CEOs' financial background on enterprise digital transformation. Compared with that of state-owned enterprises, the inhibitory effect of CEOs' financial background is more substantial for the digital transformation of nonstate- owned enterprises. For nonheavily polluting enterprises, the inhibitory effect of the CEO's financial background on the digital transformation of enterprises is more significant. For the digital transformation of digital economy enterprises, the effect of the CEO's financial background is insignificant, whereas for the digital transformation of enterprises in the nondigital economy, the CEO's financial background has a significant inhibitory effect.

8.2 Policy Implications and Research Limitations

Suppose that the CEO of a listed company has a financial background. In that case, it is recommended that the CEO proactively strengthen R&D investment and try to avoid excessive financialization of the enterprise during the critical stage of digital transformation. For nonstate-owned enterprises, nonheavily polluted enterprises, and nondigital economic enterprises, CEOs with financial backgrounds should be carefully selected and hired while promoting digital transformation. The management and guidance of CEOs with financial backgrounds should be strengthened.

The regression results for insufficient research on the financial background of CEOs have not been sufficiently validated. For example, in the robustness test, the results of lagged explanatory variables and simultaneous lagged control variables are not significant enough, although they are consistent with the main effect. Additionally, although the mediating effects of some mediating variables are relatively apparent for the mechanism of action test, the Sobel test results are not significant enough. For further heterogeneity analysis, although the results of the group regression are significantly different, the coefficient of difference between the groups is also not significant enough. The CEO's financial background has a specific inhibitory effect on enterprise digital transformation, but the mechanism of action and heterogeneity analysis are not significant enough. In the future, we will further improve the data on the CEO's financial background and explore the boundary conditions for the role of CEO financial branding.

REFERENCES

Bu, Y., Du, X., Wang, Y., Liu, S., Tang, M., & Li, H. (2024). Digital inclusive finance: A lever for SME financing? *International Review of Financial Analysis*, *93*, 103115. https://doi.org/10.1016/j.irfa.2024.103115

Ghardallou, W., Borgi, H., & Alkhalifah, H. (2020). CEO characteristics and firm performance: A study of saudi arabia listed firms. *The Journal of Asian Finance, Economics and Business, 7*(11), 291–301. https://doi.org/10.13106/jafeb.2020.vol7.no11.291

Hua, Z., & Yu, Y. (2023). Digital transformation and the impact of local tournament incentives: Evidence from publicly listed companies in China. *Finance Research Letters, 57*, 104204. https://doi.org/10.1016/j.frl.2023.104204

Jiang, X., Zhu, J., Akbar, A., Hou, Z., & Bao, X. (2022). The dark side of executives' professional background: Evidence from Chinese firm's stock price crash risk. *Managerial and Decision Economics, 43*(8), 3771–3784. https://doi.org/10.1002/mde.3627

Kalelkar, R., & Khan, S. (2016). CEO financial background and audit pricing. *Accounting Horizons, 30*(3), 325–339. https://doi.org/10.2308/acch-51442

Liu, B., Zhou, W., Chan, K. C., & Chen, Y. (2020). Corporate executives with financial backgrounds: The crowding-out effect on innovation investment and outcomes. *Journal of Business Research, 109*, 161–173. https://doi.org/10.1016/j.jbusres.2019.11.055

Liu, G., & Wang, S. (2023). Digital transformation and trade credit provision: Evidence from China. *Research in International Business and Finance, 64*, 101805. https://doi.org/10.1016/j.ribaf.2022.101805

Oradi, J., Asiaei, K., & Rezaee, Z. (2020). CEO financial background and internal control weaknesses. *Corporate Governance: An International Review, 28*(2), 119–140. https://doi.org/10.1111/corg.12305

Wei, L., & Li, M. (2024). Digital transformation, financing constraints and firm growth performance–from the perspective of financing channels. *Finance Research Letters, 63*, 105272. https://doi.org/10.1016/j.frl.2024.105272

Xie, Z., Du, J., & Wu, Y. (2022). Does financialization of nonfinancial corporations promote the persistence of innovation: Evidence from a-share listed manufacturing corporations in China. *Eurasian Business Review, 12*(2), 229–250. https://doi.org/10.1007/s40821-021-00193-x

Xu, P., & Zhang, Z. (2023a). Facilitation or inhibition? Impact of CEO's financial background on industrial AI transformation of manufacturing companies. *Frontiers in Psychology, 14*. https://doi.org/10.3389/fpsyg.2023.1126801

Xu, P., & Zhang, Z. (2023b). Facilitation or inhibition? Impact of CEO's financial background on industrial AI transformation of manufacturing companies. *Frontiers in Psychology, 14*. https://doi.org/10.3389/fpsyg.2023.1126801

Zhang, W., Lu, C., & Liang, S. (2023). More words but less investment: Rookie CEOs and firms' digital transformations. *China Journal of Accounting Research, 16*(3), 100305. https://doi.org/10.1016/j.cjar.2023.100305

Ding, Yifan, Zhu, Jiaming, & Ma, Yunfei. 2011 A new species of the genus Pseudourostyla (Hymenoptera, Braconidae) from China. (2023). The power of scholars: CEO academic experience and corporate digital transformation. Finance & Economics, 2023(6), 71-83. https://doi.org/10.19622/j.cnki.cn36- 1005/f.2023.06.006

Wan, Liangyong, Yuanyuan Cha, & Jing Rao. (2020). Financialization of Real Firms and Firms' Innovation Output - A Moderated Mediation Effect. Accounting Research, 2020(11), 98-111. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname =CJFDLAST 2021&filename= KJYJ202011008&v=

Ren, Xiaoyi, Zhiyuan Ning, & Fei Wu. (2022). Corporate Financialization and Digital Transformation - Identification and Examination Based on Digitized Textual Information of Listed Enterprises' Annual Reports. Economics and Management, 36(3), 84-92. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST 2022&filename=JJGL202203010& v=

Liu, L., Hu, W. X., & Wang, F. Y.. (2022). The impact of CEO financial background on business credit financing: the mediating effect of overconfidence. Business Economics, 41(7), 149-160. https://doi.org/10.13529/j.cnki.enterprise.economy.2022.07.015

Shi, Xuezhi & Yang, Zhen. (2021). Corporate financialization and corporate innovation: A re-examination from an industrial policy perspective. Research Management, 42(4), 147-157. https://doi.org/10.19571/j.cnki.1000-2995.2021.04.016

Wu, Fei, Hu, Huizhi, Lin, Huiyan, & Ren, Xiaoyi. (2021). Corporate digital transformation and capital market performance - Empirical evidence from stock liquidity. Management World, 37(7), 130-144,10. https://doi.org/10.19744/j.cnki.11- 1235/f.2021.0097

Zhou, Jinpei. (2020). The Impact of CEO Financial Background on Business Performance Based on Propensity Score Matching (PSM) and Logit Models. Finance Theory and Practice, 41(4), 70-77. https://doi.org/10.16339/j.cnki.hdxbcjb.2020.04.010

Tang, Song, Su, Xuesha, & Zhao, Dany. (2022). Financial Technology and Enterprise Digital Transformation - Based on Enterprise Lifecycle Perspective. Financial Science, 2022(2), 17-32. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2022&filename=CJKX202202002 &v=

Sun, Puyang, Hou, Xinyu, & Sheng, Bin. (2018). Services liberalization, managerial efficiency and firm exports. Economic Research, 53(7), 136-151. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST 2018&filename=JJYJ201807011 &v=

Chang, Yunyi, Zhou, Yuanyuan, & Zhu, Xi'an. (2022). An empirical test of the relationship between CEO financial background and asset financialization in real firms. Statistics and Decision Making, 38(6), 164-168. https://doi.org/10.13546/j.cnki.tjyjc.2022.06.033

Zhang, Yongshen, Li, Xiaobo, & Xing, Mingqiang. (2021). Corporate Digital Transformation and Audit Pricing. Auditing Research, 2021(3), 62-71. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2021&filename=SJYZ202103009 &v=

Zhang, Lina, Su, Xuesha, & Yuan, Lei. (2021). Supply Chain Finance and Firms' Digital Transformation - Heterogeneous Characteristics, Channel Mechanisms, and Differential Effects in a Non-Trust Environment. Research in Financial Economics, 36(6), 51-67. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2022 &filename= JIRO202106004&v=

Zeng, Zhuoran, Renjie Han, & Ren, Yuewen. (2021). Firm management efficiency, government subsidies and technological innovation. Statistics and Decision Making, 37(2), 181-184. https://doi.org/10.13546/j.cnki.tjyjc.2021.02.039

Li, Jian, Yang, Beibei, & Pan, Zhen. (2016). Product market competition, management shareholding and management efficiency - A study based on panel data of Chinese manufacturing firms. Journal of Guangdong University of Finance and Economics, 31(5), 72-83. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2016&filename= SONG201605008&v=

Li, G., Fang, K., & Xiao, T. S.. (2021). CEO financial background and corporate innovation: promotion or inhibition? Accounting and Economic Research, 35(5), 43-61. https://doi.org/10.16314/j.cnki.31-2074/f.2021.05.002

Li, Tang, Dong, Yiming, & Wang, Zeyu. (2018). Management Efficiency, Quality Capability and Firm Total Factor Productivity: An Empirical Study Based on the Chinese Firm-Labor Matching Survey. Management World, 34(7), 86-99,184. https://doi.org/10.19744/j.cnki.11-1235/f.2018.07.008

Du, Y., Zhang, H., & Chen, J.Y.. (2017). The impact of financialization on the future main business development of real firms:promotion or inhibition. China Industrial Economy, 2017(12), 113-131. https://doi.org/10.19581/j.cnki.ciejournal.20171214.007

Du, Y., Xie, J., & Chen, J. Y.. (2019). CEO financial background and financialization of real firms. China Industrial Economy, 2019(5), 136-154. https://doi.org/10.19581/j.cnki.ciejournal.2019.05.008

Yang, Jisheng & Yang, Jianhui. (2015). Administrative monopoly, political patronage and excess costs of state-owned enterprises. Economic Research, 50(4), 50-61,106. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST 2015&filename=JJYJ201504004&v=

Lin, Z. A. & Tao, X. H.. (2021). CEO financial background and corporate goodwill impairment risk. Accounting Newsletter, 2021(10), 25-28,34. https://doi.org/10.16144/j.cnki.issn1002-8072.2021.10.004

Mao, J., J. Li, & B. Zhang. (2022). CEO Composite Functional Context and Digital Transformation of Enterprises. Modern Finance and Economics (Journal of Tianjin University of Finance and Economics), 9, 37-58. https://doi.org/10.19559/j.cnki.12-1387.2022.09.002

Wang, H. M., Sun, P. B., & Guo, H. F.. (2022). How Digital Finance Enables Digital Transformation of Enterprises? --Empirical evidence from Chinese listed companies. Journal of Finance and Economics, 2022(10), 3-13. https://doi.org/10.13762/j.cnki.cjlc.20220311.001

Wang, Panna & Xu, Botao. (2019). CEO financial background and the level of corporate cash holdings: input or capture. Finance & Accounting Monthly, 2019(16), 22-27. https://doi.org/10.19641/j.cnki.42-1290/f.2019.16.004

Qi, Huaijin, Cao, Xiuqin, & Liu, Yanxia. (2020). The Impact of Digital Economy on Corporate Governance - Based on the Perspective of Information Asymmetry and Irrational Behavior of Managers. Reform, 2020(4), 50-64. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2020&filename=REFO202004005&v =

Xiao, Tusheng, Ruiqi Sun, Yuan Chun, & Jian Sun. (2022). Firm digital transformation, human capital restructuring and labor income share. Management World, 38(12), 220-237. https://doi.org/10.19744/j.cnki.11-1235/f.2022.0174

Hu, H. F., Dou, B., & Wang, A. P.. (2020). Corporate financialization and productivity. World Economy, 43(1), 70-96. https://doi.org/10.19985/j.cnki.cassjwe.2020.01.006

Yuan, Zeming, Lu, Xinyuan, Li, Meng, & Wang, Guiping. (2023). CEO power and corporate digital transformation: Facilitating or inhibiting. Finance and Economics Monthly, 44(12), 153-160. https://doi.org/10.19641/j.cnki.42-1290/f.2023.12.020

Xu, Chenxi, Liu, Xiaonan, & Meng, Dahu. (2023). Mixed ownership reform, corporate management efficiency and innovation sustainability in state-owned enterprises. Journal of Beijing Technology and Business University (Social Science Edition), 4, 89-100. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2023&filename= BJSB202304008&v=

Chen, Deqiu & Zhang, Wenyu. (2023). Corporate digital transformation and management incentives. Economic Management, 45(5), 132-150. https://doi.org/10.19616/j.cnki.bmj.2023.05.008

Wei, Y. J., Yin, F., & Zhong, Juan. (2023). Can CEO social capital help firms' digital transformation. Research in Financial Economics, 38(4), 92-106. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2023&filename=JIRO202304006&v=

Huang, D. Y., Xie, E. B., Meng, X. Y., & Zhang, Q. Y.. (2021). Digital Transformation and Firm Value - Empirical Evidence Based on a Textual Analysis Approach. The Economist, 2021(12), 41-51. https://doi.org/10.16158/j.cnki.51-1312/f.2021.12.006

Huang, D. Y., Xie, E. B., & Zou, M. T.. (2022). Does financialization inhibit firms' digital transformation? --Evidence and Mechanism Explanation. Modern Finance and Economics (Journal of Tianjin University of Finance and Economics), 7, 57-73. https://doi.org/10.19559/j.cnki.12-1387.2022.07.004

DIGITAL TOOLING WITH SOFT POWER TO DRIVE THE SMART SILVER ECONOMY UNDER THE AGED SOCIETY OF THAILAND

Kamolrat Intaratat[A], Piyachat Lomchavakarn[B], Karn Boonsiri[C], Duangkamol Intaratat[D]

ABSTRACT

"Thailand 4.0" is the current national strategic plan driven by digital technology and innovation, "Silver Economy" is one among the urgent flagship to serve the urgent needs of aged society with its approximately 20-30 percent of Thai population. Besides, around 60 percent of the elderly proven being under the poverty line. Most of the urgent demands is economics opportunities, digital skills, and health care, respectively. Objectives are 1) the current situation of elderly towards "Silver Economy" embedded with "Soft Power"; 2) the digital literacy & competency skills of elderly towards "Silver Economy" embedded with "Soft Power"; and 3) the recommendation to support the elderly towards "Silver Economy" embedded with "Soft Power". Mix research methods were used 1) Quantitative research by e-survey among the 100 elderly across the country who involved with Silver Economy and Soft Power. Qualitative research by in-depth-interview and Focus Group Discussion among 15 key informants from the elderly and all stakeholders. Results found 1) most of the elderly have a very good attitude, high demands to run their Silver Economy activities especially with their own Soft Power; 2) most of the elderly gain fundamental digital literacy & competency. More digital top skills are needed to run their Silver Economy activities i.e. creative digital marketing skills, AI in digital PR, digital story telling, and local tourism, etc. and 3) Recommendations for more tangible collaborations among all the relevant stakeholders from policy to the practical agencies. Friendly and effective portal for all kinds of collaborations among the stakeholders and the elderly themselves.

Keywords: *Digital Tooling, Soft Power, Smart Silver Economy, Aged Society of Thailand*

[A] *Ph.D., School of Communication Arts, CCDKM, STOU, Thailand. Email: kamolratchim@gmail.com Orcid: https://orcid.org/0000-0001-7783-4888*

[B] *Ph.D., School of Communication Arts, STOU, Thailand. Email: ningpiyachat@yahoo.com Orcid: https://orcid.org/0009-0004-2088-7865*

[C] *Ph.D., School of Communication Arts, STOU, Thailand. Email: karnboonsiri@gmail.com Orcid: https://orcid.org/0009-0009-1923-2745*

[D] *Ph.D. Candidate, School of Communication Arts, CCDKM, STOU, Thailand. Email: ccdkm.pui@gmail.com Orcid: https://orcid.org/0009-0007-8966-3984*

FORECASTING OTOP PRODUCT SALES USING TIME SERIES ANALYSIS AND MACHINE LEARNING

Songpol Khuptachit[A], Suwannee Adsavakulchai[B]

ABSTRACT

This research aims to forecast OTOP product sales to increase sales opportunities using machine learning. The study follows the CRISP-DM methodology, from understanding the problem to practical implementation. In this study divided into 2 parts. 1. forecast OTOP product sales using time series analysis. According to OTOP Products is not forecasting future trends, by using 76 provinces OTOP products Sales from January 2018 to May 2024 prepared for analysis. Forecasting uses time series with Google Colaboratory. Five algorithms for forecasting OTOP product sales are ARMA, ARIMA, SARIMA, LSTM, and Prophet. The results demonstrated that SARIMA is the AIC (Akaike Information Criterion) and MAE (Mean Absolute Error) 1223.28 and 15883.119, respectively. Comparing with ARMA and ARIMA which AIC values of 1842.87 and 1820.61, respectively. Additionally, LSTM and Prophet are MAE values of 36616.156 and 74953.975, respectively. 2. To increase sales opportunities using Weka as a tool, the study examined factors influencing OTOP product sales using three algorithms that are Decision Tree (DT), Naive Bayes (NB), and Support Vector Machine (SMO). The findings indicated that product type, consumer type and distribution channel significantly affect OTOP sales. The DT (J48) algorithm achieved the highest accuracy of 96.63% compared to SMO and NB which accuracies of 89.68% and 76.84%, respectively. It can be concluded that SARIMA algorithm is the most suitable for forecasting OTOP product sales, predicting an overall increase in sales over the next five years (2025-2029). Decision Tree is the most suitable model for sales opportunities. The priority promotes food products for Thai consumers through offline. The second priority promotes clothing products for Thai consumers through offline. Further study can be utilized to enhance the sales of OTOP products.

Keywords: *OTOP products sales, Machine Learning, time series, Decision tree*

INTRODUCTION

One Tambon One Product (OTOP) project in Thailand adopted from Japan (Oita International Center: OIC). The OTOP project represented the Thai cultural identity of each locality and possesses significant export potential. The main purpose of OTOP is to transform the local wisdom into unique products and stimulates the Thai economy. Therefore, the government provided knowledge, enhanced local wisdom, and improved management practices to facilitate the connection of community-based products to markets through retail

[A] *School of Engineering, University of the Thai Chamber of Commerce Email: 230731303003@live4.utcc.ac.th*
[B] *School of Engineering, University of the Thai Chamber of Commerce Email: suwannee_ads@utcc.ac.th*

stores and online channels. In addition, Thai government promotes the investment and enhances the visibility of OTOP products in international markets. [1]

Machine learning is a significant role in various industries. In the fashion retail industry, deep learning has been used to forecast demand [2]. In manufacturing, machine learning applied for predictive maintenance all machine i.e. cooling tower, etc. In education, machine learning to support all teachers to evaluation all students for improve curriculum. In health technology, machine learning support doctors to make decision for diagnostics. In this study, machine learning will be applied to analyze the factors influencing OTOP product sales.

Time series analysis is employed to understand the patterns, trends, seasonality, and characteristics of data over time. It can be used for forecasting and future decision-making. Examples of time series analysis techniques include forecasting (using ARIMA, SARIMA, and LSTM models to predict future values based on historical data), trend analysis (identifying long-term trends or directions in the data), and seasonality analysis (examining fluctuations that occur at specific time intervals, such as seasonal cycles). [3]

The objectives of this study are 1. To forecast OTOP product sales using time series analysis. 2. To analyze the factors influencing OTOP product sales using machine learning.

RESEARCH METHODOLOGY

This study is divided into two parts: 1. Forecasting OTOP product sales using time series analysis and 2. To analyze the factors influencing OTOP product sales using machine learning. The standard CRISP-DM data mining process is followed:

1. Forecasting OTOP product sales using time series analysis

1.1 Problem Understanding

This step involves understanding the issue of declining OTOP product sales during the COVID-19 pandemic in Thailand. Additionally, the focus is on forecasting OTOP product sales using monthly sales data from 2018 to May 2024.

1.2 Data Understanding

Data is collected from the website of the Department of Community Development, Ministry of the Interior. Monthly OTOP product sales data (including online sales) from 2018 to May 2024 is gathered.

1.3 Data Preparation

Data from various sources is consolidated into a single table for analysis. This step involves:

a. Feature Selection

The reliable monthly OTOP sales data from the Department of Community Development is selected.

b. Data Transformation

Data is transformed into a suitable format for analysis. For example, total sales are divided by 100,000 to reduce the magnitude of numbers and improve readability. Data is also formatted as "Date" and "Value" for further analysis.

1.4 Modeling

Five different machine learning algorithms are used for forecasting: ARMA, ARIMA, SARIMA, LSTM, and Prophet.

1.5 Evaluation

The performance of ARMA, ARIMA, and SARIMA models is evaluated using the Akaike Information Criterion (AIC). The model with the lowest AIC value is

considered the best. The performance of LSTM and Prophet models is evaluated using Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE).

1.6 Deployment
The chosen model can be used to forecast OTOP product sales and analyze sales trends to support future planning.

2. The factors influencing OTOP product sales using machine learning

2.1 Problem Understanding
his step involves understanding the decline in OTOP product sales during the COVID-19 pandemic in Thailand. Additionally, the study focuses on identifying specific product categories that significantly impact overall OTOP sales.

2.2 Data Understanding
Data is collected from the Department of Community Development's website, specifically annual OTOP sales data categorized into five product types: food, beverages, clothing, home decor, and non-food herbal products, and divided into three time periods: 2018-2019, 2020-2021, and 2022-2023.

2.3 Data Preparation
Data from various sources is consolidated into a single table for analysis. This involves:

a. Feature Selection
The annual OTOP sales data categorized into five product types is selected.

b. Data Transformation
Data is transformed using K-means clustering in Weka to group data into five clusters. These clusters are then named for easier analysis.

2.4 Modeling
Three machine learning algorithms are used to identify factors affecting OTOP sales: Decision Tree (J48), Naive Bayes (NB), and Support Vector Machine (SMO).

2.5 Evaluation
The performance of these algorithms is evaluated using the following metrics: Accuracy, Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), True Positive Rate (TPR), False Positive Rate (FPR), Precision, F-Measure (F1-Score), and Matthews Correlation Coefficient (MCC).

2.6 Deployment
The results can be used to analyze which product categories have the most significant impact on OTOP sales, informing sales and marketing strategies.

RESULTS

1. Forecasting OTOP product sales using time series analysis

1.1 Problem Understanding
Given the seasonal nature of OTOP product sales (Figure 1), accurate forecasting can aid in assessing future sales, developing new products, and implementing effective sales strategies.

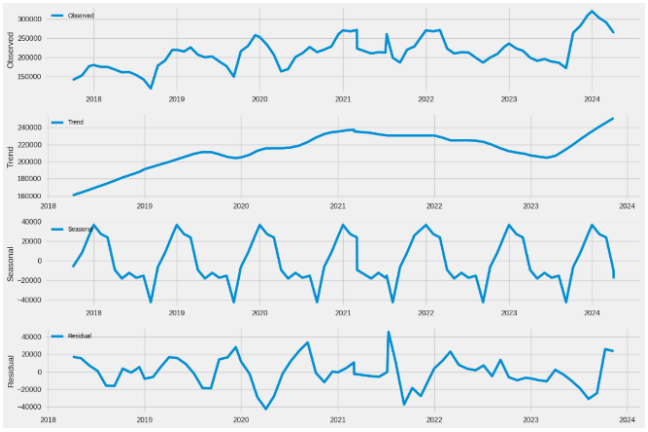


Figure 1 – Seasonal pattern of monthly OTOP sales from 2018 to May 2024

1.2 Data Understanding

Monthly OTOP sales data for 76 provinces across 18 administrative regions from 2018 to May 2024 was analyzed. Nakhon Pathom recorded the highest sales, followed by Chiang Mai, Ratchaburi, Khon Kaen, Nakhon Ratchasima, Udon Thani, Ubon Ratchathani, Sisaket, Phetchaburi, and Samut Prakan (Figure 2).

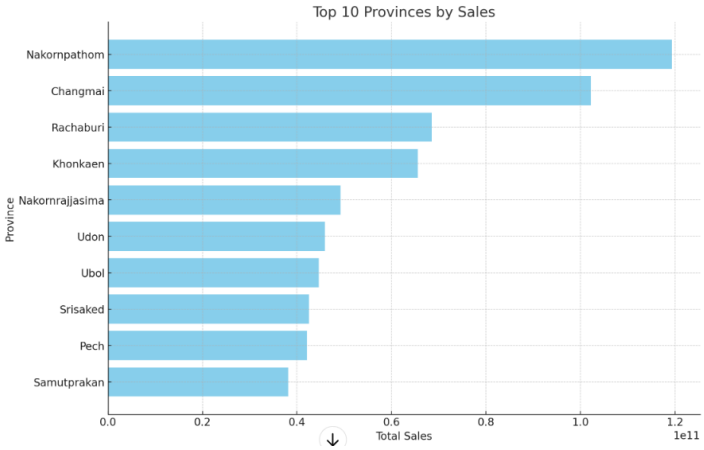


Figure 2 – Top 10 provinces with the highest OTOP sales from 2018 to May 2024

1.3 Data Preparation

Monthly OTOP sales data from 2018 to May 2024 was consolidated into two columns: "Date" and "Value".

1.4 Model Development

Five forecasting models were applied: ARMA, ARIMA, SARIMA, LSTM, and Prophet. The results are shown in Figure 3-7.

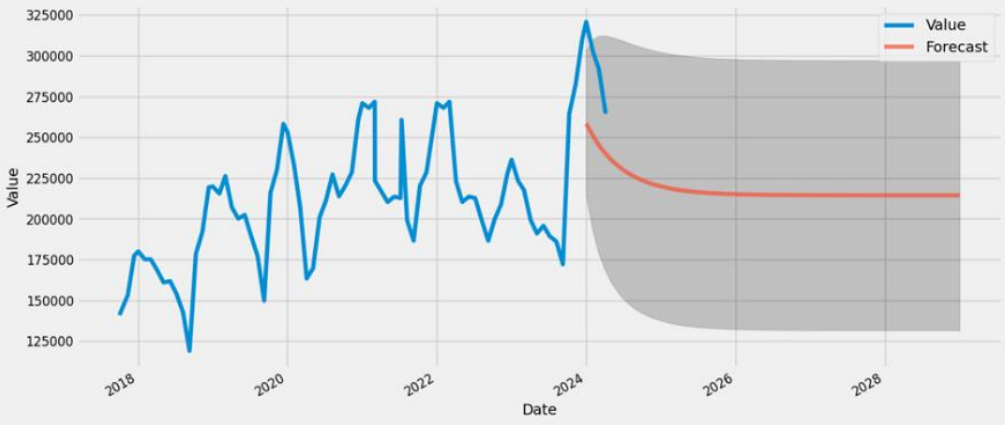


Figure 3 – Forecast plots for ARMA models

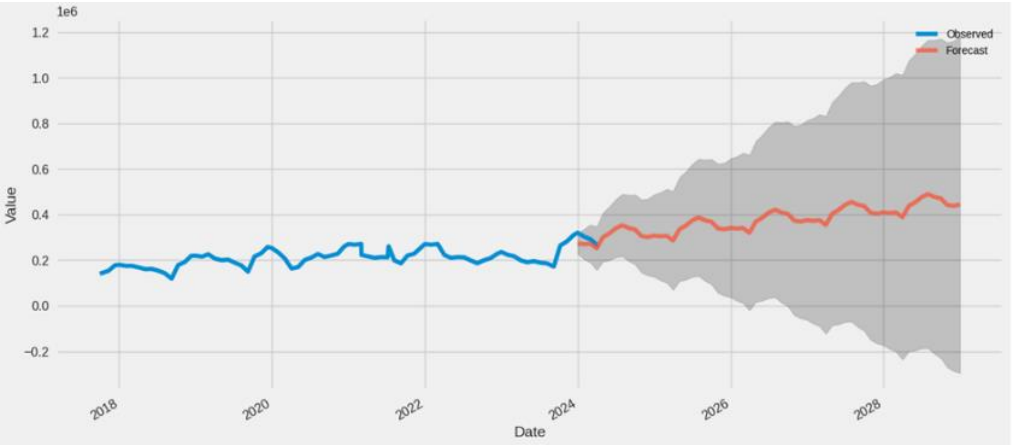


Figure 4 – Forecast plots for ARIMA models

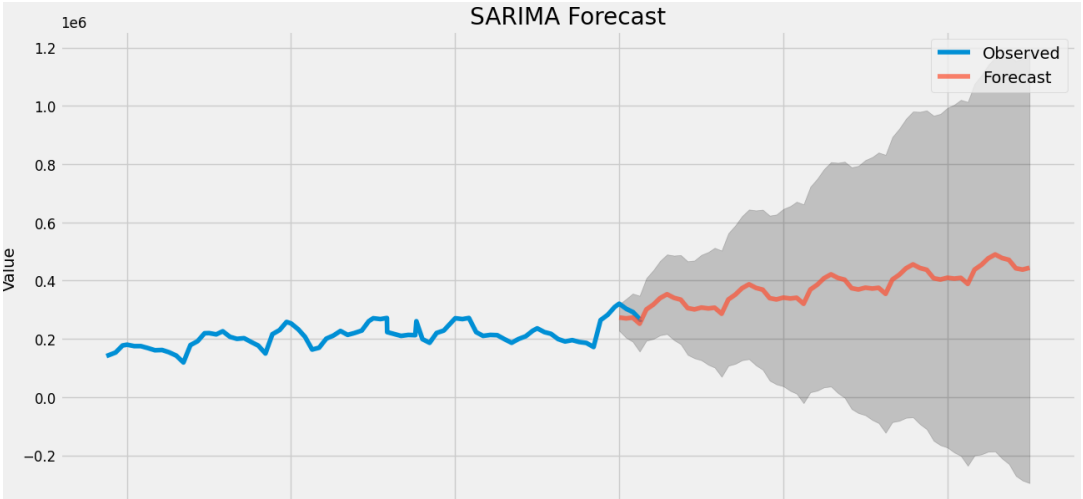


Figure 5 – Forecast plots for SARIMA models

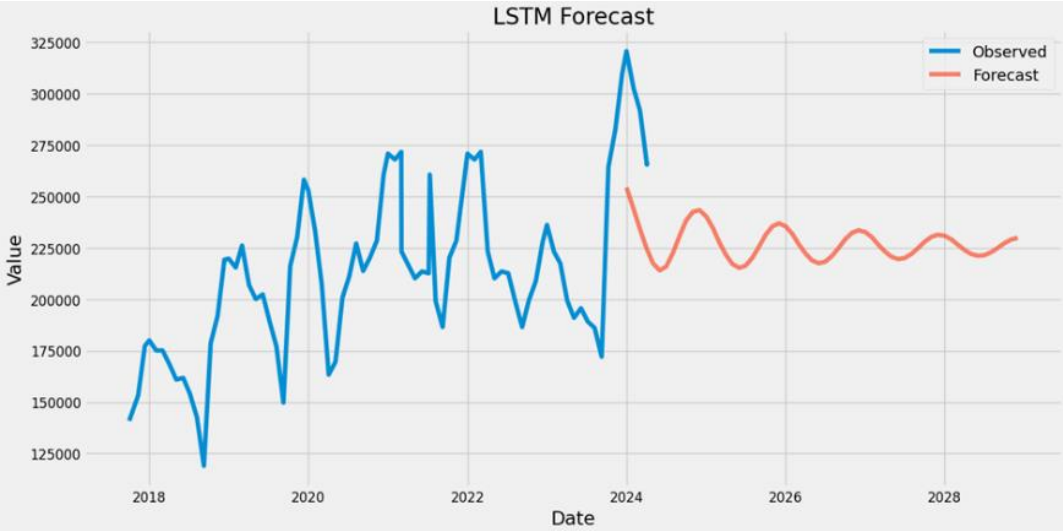


Figure 6 – Forecast plots for LSTM models

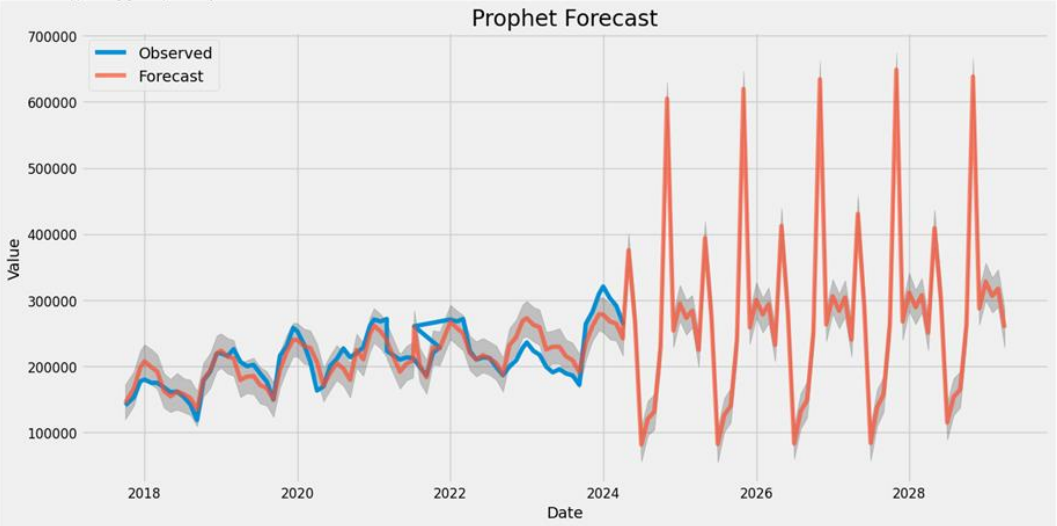


Figure 7 – Forecast plots for Prophet models

1.5 Model Evaluation

SARIMA outperformed other models with the lowest AIC value of 1223.281. When comparing SARIMA, LSTM, and Prophet based on MAE and RMSE, SARIMA again showed the best performance.

Table 1 – Comparison of AIC for ARMA, ARIMA, and SARIMA

Model	AIC
ARMA	1842.866
ARIMA	1820.612
SARIMA	1223.281

Table 2 – Comparison of MAE and RMSE for SARIMA, LSTM, and Prophet]

Model	MAE (Mean Absolute Error)	RSME (Root Mean Square Error)
SARIMA	15883.11908	25801.29916
LSTM	36616.15625	38600.54365
Prophet	74953.97479	74953.97479

1.6 Deployment
The SARIMA model can be used to forecast future OTOP sales, enabling better inventory management, promotional planning, and pricing strategies.

2. The factors influencing OTOP product sales using machine learning

2.1 Problem Understanding
OTOP products reflect local cultures and generate income for communities. By categorizing products into various types like food, beverages, and handicrafts, we can identify specific products that significantly impact overall sales, thus supporting decision-making for sales growth.

2.2 Data Understanding
Annual OTOP sales data for five product categories (food, beverages, clothing, home decor, and non-food herbs) across 76 provinces was analyzed from 2018 to 2026. Food products consistently had the highest sales, while non-food herbs had the lowest (Figure 8).

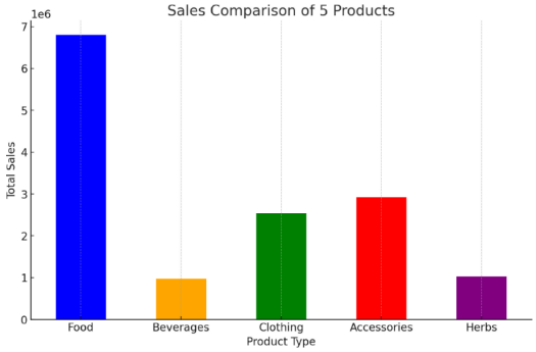


Figure 8 – Bar chart comparing sales of different product categories]

2.3 Data Preparation
K-means clustering was used to group similar products. The resulting five clusters were labeled Class A to Class E based on their sales ranges (Figure 9) and Table 6.

```
Final cluster centroids:
                                        Cluster#
Attribute                  Full Data           0             1             2             3             4
                             (456.0)      (87.0)        (17.0)        (45.0)       (172.0)       (135.0)
=============================================================================================================
province                         Non     Chacheng     Nakornpathom          Pech         Patum          Lop
total             3327411403.5088  4185981609.1954 15788352941.1765  7184006666.6667  1274498837.2093  2534985925.9259



Time taken to build model (full training data) : 0.01 seconds

=== Model and evaluation on training set ===

Clustered Instances

0       87 ( 19%)
1       17 (  4%)
2       45 ( 10%)
3      172 ( 38%)
4      135 ( 30%)
```

Figure 9 – K-means clustering results

Table 6 – OTOP sales grouped by cluster

province	total	Cluster
Non	1,632,800,000.00	cluster3
Patum	1,138,600,000.00	cluster3
Ayuttaya	3,715,300,000.00	cluster0
Sara	1,476,300,000.00	cluster3
Angthong	1,487,000,000.00	cluster3
Lop	1,921,000,000.00	cluster4
Sing	488,900,000.00	cluster3
Chainat	793,900,000.00	cluster3
Samutprakan	3,808,300,000.00	cluster0
Chacheng	3,295,400,000.00	cluster0
Prachin	2,906,800,000.00	cluster4

From Table 6, there are 5 clusters: clusters0, clusters1, cluster2, clusters3, clusters 4 and Map each Cluster as follows

< 1,910,000,000 baht	cluster3 namely Class A
1,910,000,000 - 3,364,900,000 baht	cluster4 namely Class B
3,364,900,001 - 5,695,000,000 baht	cluster1 namely Class C
5,695,000,001 - 12,000,000,000 baht	cluster3 namely Class D
> 12,000,000,000 baht	cluster3 namely Class E

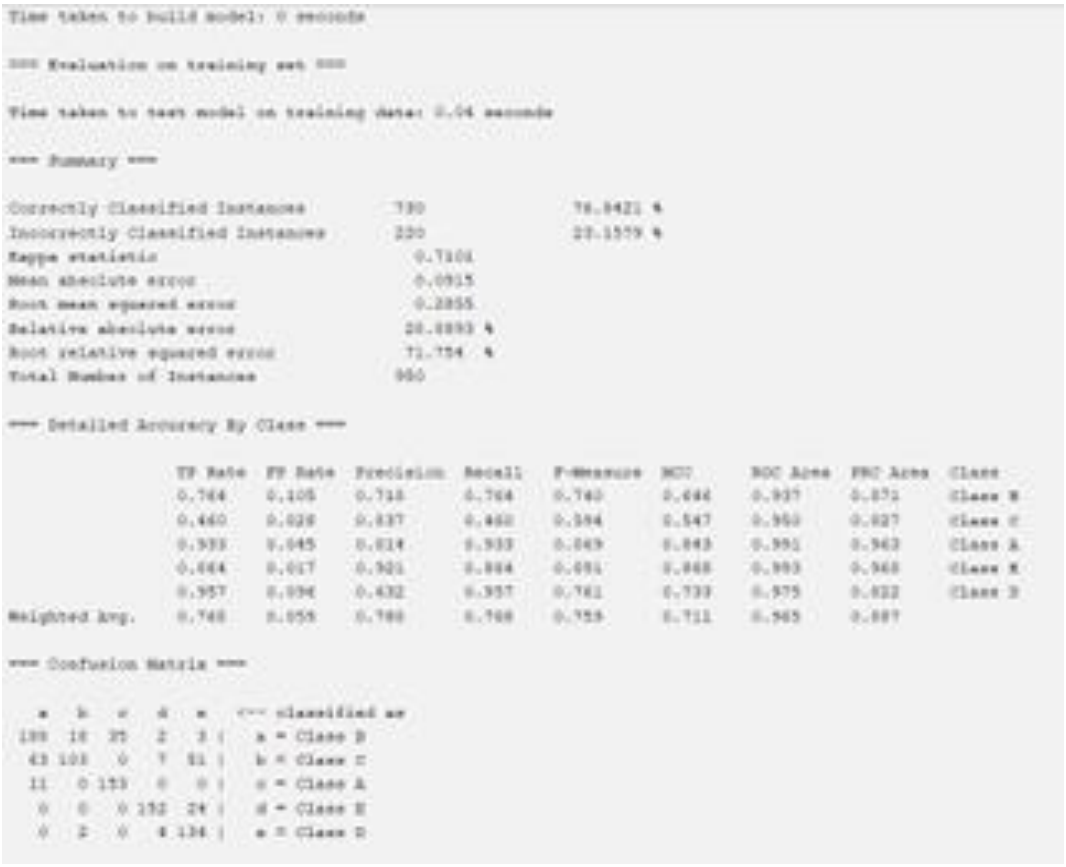
2.4 Model Development

Decision Tree (J48), Naive Bayes, and SMO algorithms were used to identify factors influencing OTOP sales The results are shown in Figure 10-13.

- Decision Tree (J48): Accuracy of 96.6316%.
- Naive Bayes: Accuracy of 76.8421%.
- SMO: Accuracy of 89.6842%.

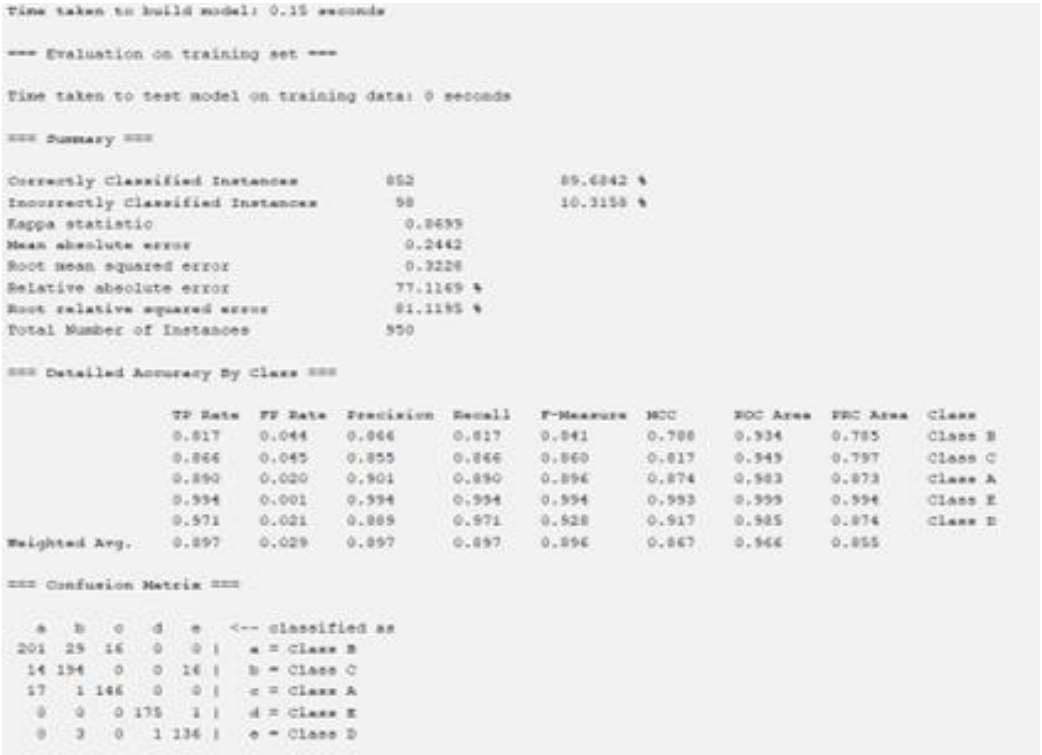
```
Time taken to build model: 0.02 seconds

=== Evaluation on training set ===

Time taken to test model on training data: 0 seconds

=== Summary ===

Correctly Classified Instances         918               96.6316 %
Incorrectly Classified Instances        32                3.3684 %
Kappa statistic                          0.9576
Mean absolute error                      0.0244
Root mean squared error                  0.1105
Relative absolute error                  7.7126 %
Root relative squared error             27.7723 %
Total Number of Instances              950

=== Detailed Accuracy By Class ===

               TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
               0.963    0.007    0.979      0.963    0.971      0.961    0.994     0.979     Class B
               0.897    0.003    0.990      0.897    0.941      0.926    0.987     0.958     Class C
               1.000    0.009    0.959      1.000    0.979      0.975    0.996     0.962     Class A
               1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     Class E
               1.000    0.022    0.886      1.000    0.940      0.931    0.989     0.886     Class D
Weighted Avg.  0.966    0.007    0.968      0.966    0.966      0.958    0.993     0.962

=== Confusion Matrix ===

   a   b   c   d   e   <-- classified as
 237   2   7   0   0 |   a = Class B
   5 201   0   0  18 |   b = Class C
   0   0 164   0   0 |   c = Class A
   0   0   0 176   0 |   d = Class E
   0   0   0   0 140 |   e = Class D
```

Figure 10 – Decision Tree (J48) results



```
Time taken to build model: 0 seconds

=== Evaluation on training set ===

Time taken to test model on training data: 0.04 seconds

=== Summary ===

Correctly Classified Instances         730               76.0421 %
Incorrectly Classified Instances       230               23.9579 %
Kappa statistic                          0.7104
Mean absolute error                      0.0915
Root mean squared error                  0.2855
Relative absolute error                 20.8893 %
Root relative squared error             71.754  %
Total Number of Instances              960

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   MCC      ROC Area  PRC Area  Class
               0.764     0.105     0.718     0.764     0.740     0.646     0.937     0.871     Class B
               0.460     0.028     0.837     0.460     0.594     0.547     0.950     0.827     Class C
               0.933     0.045     0.814     0.933     0.869     0.843     0.991     0.963     Class A
               0.664     0.017     0.921     0.884     0.651     0.668     0.993     0.968     Class E
               0.957     0.096     0.632     0.957     0.761     0.733     0.975     0.822     Class D
Weighted Avg.  0.760     0.058     0.780     0.760     0.759     0.711     0.965     0.887

=== Confusion Matrix ===

   a   b   c   d   e   <-- classified as
 139  18  25   2   3 |   a = Class B
  43 103   0   7  51 |   b = Class C
  11   0 173   0   0 |   c = Class A
   0   0   0 152  24 |   d = Class E
   0   2   0   4 134 |   e = Class D
```

Figure 11 – Naive Bayes results



```
Time taken to build model: 0.15 seconds

=== Evaluation on training set ===

Time taken to test model on training data: 0 seconds

=== Summary ===

Correctly Classified Instances         852               89.6842 %
Incorrectly Classified Instances        98               10.3158 %
Kappa statistic                          0.8699
Mean absolute error                      0.2442
Root mean squared error                  0.3228
Relative absolute error                 77.1169 %
Root relative squared error             81.1195 %
Total Number of Instances              950

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   MCC      ROC Area  PRC Area  Class
               0.817     0.044     0.866     0.817     0.841     0.788     0.934     0.785     Class B
               0.866     0.045     0.855     0.866     0.860     0.817     0.949     0.797     Class C
               0.890     0.020     0.901     0.890     0.896     0.874     0.983     0.873     Class A
               0.994     0.001     0.994     0.994     0.994     0.993     0.999     0.994     Class E
               0.971     0.021     0.889     0.971     0.928     0.917     0.985     0.874     Class D
Weighted Avg.  0.897     0.029     0.897     0.897     0.896     0.867     0.966     0.855

=== Confusion Matrix ===

   a   b   c   d   e   <-- classified as
 201  29  16   0   0 |   a = Class B
  14 194   0   0  16 |   b = Class C
  17   1 146   0   0 |   c = Class A
   0   0   0 175   1 |   d = Class E
   0   3   0   1 136 |   e = Class D
```

Figure 12 – SMO results

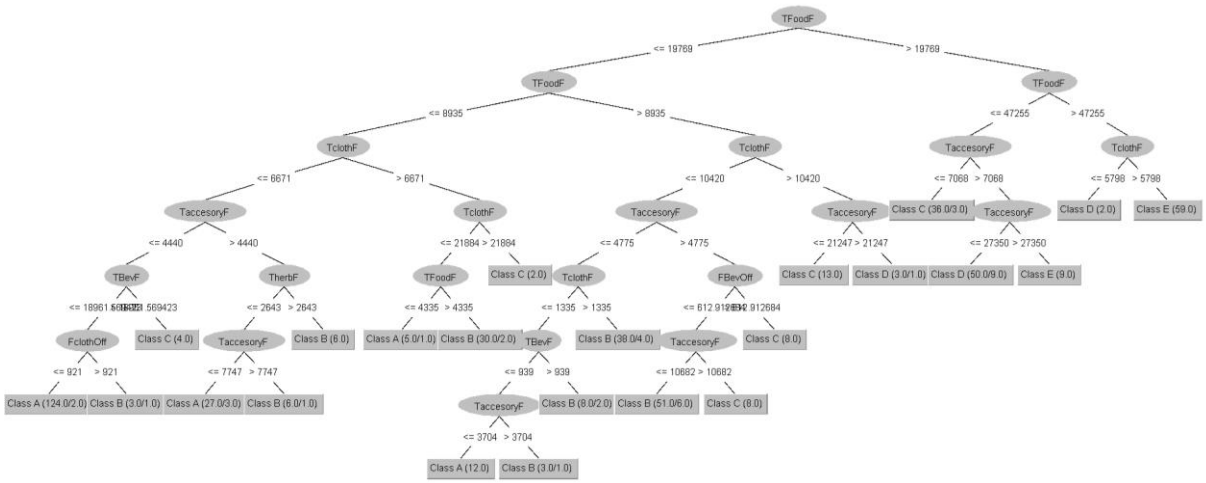


Figure 13 – Visualization tree

From Figure 13, Decision Tree (J48) algorithm, the rule-based as following:

Rule 1

If TFoodF > 19769 And TFoodF > 47255 And TclothF > 5798 Then Class = E (revenue > 12,000,000,000 baht)

Rule 2:

If TFoodF > 19769 And TFoodF > 47255 And TclothF <= 5798 Then Class = D (revenue 5,695,000,001 - 12,000,000,000 baht)

Rule 3:

If TFoodF > 19769 And TFoodF <= 47255 And TaccesoryF > 7068 And TaccoseryF > 27350 Then Class = E (revenue > 12,000,000,000 baht)

Rule 4:

If TFoodF > 19769 And TFoodF <= 47255 And TaccesoryF > 7068 And TaccoseryF <= 27350 Then Class = D (revenue 5,695,000,001 - 12,000,000,000 baht)

Rule 5:
If TFoodF > 19769 And TFoodF <= 47255 And TaccesoryF <= 7068 Then Class = C (revenue 3,364,900,001 - 5,695,000,000 baht)

2.5 Model Evaluation

Decision Tree (J48) performed best with the highest accuracy of 96.63%.

Parameters	Decision Tree: J48	Naive Bayes	SMO
Accuracy	96.6316 %	76.8421 %	89.6842 %
MAE	0.0244	0.0915	0.2442
RMSE	0.1105	0.2855	0.3228
TPR	0.966	0.768	0.897
FPR	0.007	0.059	0.029
Precision	0.968	0.788	0.897
F-Measure	0.966	0.759	0.896
MCC	0.958	0.711	0.867

By analyzing OTOP sales data and applying machine learning techniques, we can identify key factors driving sales. The derived rules can be used to guide product development, marketing strategies, and overall business decisions to boost OTOP sales.

2.6 Deployment and Implications

The results of the factor analysis can be used to determine which factors significantly impact sales, such as product type and customer segments. This information can then be used to tailor products to meet market demands and develop appropriate marketing strategies.

SUMMARY AND RECOMMENDATIONS

Forecasting OTOP product sales for the next five years (2025-2029) indicates a positive trend. The SARIMA model proved to be the most accurate for forecasting, with an AIC of 1223.281, MAE of 15883.11908, and RMSE of 25801.29916. The analysis also revealed that food products, particularly those targeting domestic consumers and sold offline, have the most significant impact on OTOP sales. This was followed by clothing products for domestic consumers sold offline. The Decision Tree (J48) algorithm, with an accuracy of 96.6316%, was most effective in identifying these factors.

The DT (J48) algorithm achieved the highest accuracy of 96.63% compared to SMO and NB which accuracies of 89.68% and 76.84%, respectively. To increase sales opportunities that product type, consumer type and distribution channel significantly affect OTOP sales. The priority promotes food products for Thai consumers through offline. The second priority promotes clothing products for Thai consumers through offline.

Further study can be utilized to enhance the sales of OTOP products.

REFERENCES

Ko Chan District Office, Chonburi Province. What is OTOP? [Internet]. May 6, 2021. Available from: https://district.cdd.go.th/kochan/%e0%b8%aa%e0%b8%b4%e0%b8%99%e0%b8%84%e0%b9%89%e0%b8%b2%e0%b9%82%e0%b8%ad%e0%b8%97%e0%b8%ad%e0%b8%9b-otop-%e0%b8%84%e0%b8%b7%e0%b8%ad%e0%b8%ad%e0%b8%b0%e0%b9%84%e0%b8%a3/

Digital Economy Promotion Agency. Machine Learning: The new world of the digital age [Internet]. June 12, 2020. Available from: https://www.depa.or.th/th/article-view/article11-2563

Nattachot Promrut and Sajjaphon Vaijaraya. (2021). "Fundamentals of Deep Learning in Practice." 1st Edition. Nonthaburi: IDC. [4] Poomthan Rangkunanuwat. (2019). https://economics.utcc.ac.th/wp-content/uploads/Time-Series-for-Econ-and-Bus_Poomthan.pdf

LEVERAGING ELECTRONIC WORD-OF-MOUTH AND TRUST TO DRIVE DIETARY SUPPLEMENT CONSUMPTION.

Paul Kalin[A], Yung-Hung Shek[B]

ABSTRACT

The surge in dietary supplements consumption among consumers represents a growing opportunity for brands to expand their market share online. However, to thrive in this increasingly competitive industry, it is essential to implement effective online marketing strategies that can drive consumption.

This study aims to investigate the determinants of dietary supplements consumption using the Elaboration Likehood Model (ELM).

Employing the convenience sampling method, online questionnaires were distributed to 400 respondents, residing in Bangkok, aged 18-45, who use social media on a regular basis. This study conducted the data analysis using the two-step procedure. First, a confirmatory factor analysis (CFA) was performed to assess the reliability and validity. Then, a structural equation modeling (SEM) was tested to verify the hypotheses.

The findings demonstrate that electronic word-of-mouth (eWOM) significantly impacts both trust and consumption. Both the quantity and quality of eWOM were found to have a substantial influence on trust and subsequent consumption. Additionally, the study revealed a significant relationship between trust and consumption.

The findings of this study guide marketers and business practitioners towards building eWOM to build trust which can ultimately drive consumption. Establishing trust between suppliers and consumers becomes vital in encouraging consumption of dietary supplements. Marketers should focus on both quality of the information in eWOM and the quantity of eWOM while designing their marketing strategies.

Keywords: *eWOM, Trust, Consumption, Dietary supplements, ELM*

INTRODUCTION

Dietary supplements refer to products that are intended enhance to a person's diet and contains dietary ingredients such as vitamins, herbs and minerals (U.S Food and Drug Administration, 2015). In reference to Nation Thailand (2023), the Thai dietary supplement market is experiencing steady growth, projected to increase from US$190 billion in 2021 to US$239 billion by 2025, at a rate of 9% per year. The convergence of factors, including an aging population, increased health and wellness awareness, and the COVID-19 pandemic, has fueled a significant rise in Thai consumer spending on dietary supplements (Malaniyom, 2024).

[A] *Lecturer, Faculty of Food Business Management, Panyapiwat Institute of Management, Nonthaburi, Thailand. Email: paulkal@pim.ac.th*

[B] *Lecturer, Faculty of Food Business Management, Panyapiwat Institute of Management, Nonthaburi, Thailand. Email: yunghungshe_pim@pim.ac.th*

For this reason, it is crucial for dietary supplement companies to understand what drives consumers to purchase dietary supplement (Zhao, Jin, & Karinshak, 2023).

Despite the abundance of online information for dietary supplements (Chou, Chen & Shen, 2024), internet users rely on online reviews rather than other media sources. (Cheung & Thadani, 2012). Therefore, recent years have seen a surge in research examining the effectiveness of eWOM. However, the existing body of research about eWOM is broad and diverse, with researchers employing various approaches to study this concept. While some reseachers shed light on the effect of word-of-mouth on brand trust as well as word-of-mouth on consumption, few studies have simultaneously investigated these relationships. This gap in research has led to a limited understanding in this field.

To address the aforementioned gaps, the current study aims to this research aims to enhance understanding of the impact of eWOM on consumers' purchase decisions on dietary supplements in Thailand. To fulfill this aim, this study will examine the effect of eWOM on consumption on dietary supplement from the perspective of elaboration likelihood model (ELM) theory and proposes a conceptual framework to examine the relationship between eWOM, trust and consumption of dietary supplement. More specifically, this study will examine the eWOM in two aspects: quality and quantity.

LITERATURE REVIEW

Elaboration Likelihood Model

The Elaboration Likelihood Model (ELM) proposed by Petty and Cacioppo (1986), represents an important tool to explain how individuals process information in persuasive communication context (Bao & Wang, 2021). The ELM theory is applied by researchers to demonstrate how information drives consumer behavior and consumer responses (Yusuf, Che Hussin & Busalim, 2018; Cheung & Thadani, 2012). ELM identified two routes (the central route and the peripheral route) that may lead to changes in an individual's attitudes and behaviours (Buchanan, Kelly & Yeatman, 2017). People who are engaged in the central route will consider argument quality whereas people who are engaged in the peripherical route will consider positive or negative cues (Zhou, Lu & Wang., 2016). Researchers have widely used ELM to explore the impact of positive eWOM on consumer behavior (Teng, Wei Khong, Wei Goh & Yee Loong Chong, 2014; Chan & Ngai, 2011). Previously, scholars have mainly used ELM theory to investigate the influence of eWOM on different types of behavior: consumer trust (Yang, 2016); participation (Bao & Wang, 2021), adoption (Shankar, Jebarajakirthy & Ashaduzzaman, 2020; Cheung & Thadani, 2012), purchase intention (Yusuf et al., 2018). ELM has been used in various contexts: cosmetics (Anubha, 2021), brand microblog (Bao & Wang, 2021), mobile banking (Shankar, Jebarajakirthy & Ashaduzzaman, 2020), social commerce (Yusuf et al., 2018). This study will use ELM to examine the effect of eWOM and trust on the consumption of dietary supplements.

e-WOM

Hennig-Thurau, Gwinner, Walsh, and Gremler (2004), defined electronic word-of-mouth (eWOM) as "any positive or negative statement made by potential, actual or former customers about a product or company that is available through the internet." Cheung and Lee (2012) mentioned that eWOM has emerged with the development of internet and digital media, and are perceived as trustworthy as information from the brand itself. eWOM plays an

important role in consumer buying and consumption behavior (Anubha, 2021; Daowd, Hasan, Eldabi, Rafi-ul-Shan, Cao, & Kasemsarn, 2020; Yusuf et al., 2018) since it allows consumers to obtain information to make decision. Over the past year, eWOM has been the focus of numerous studies with scholars examining its impact on consumer behavior through various dimension. According to Bhattacherjee and Sanford (2006), the quality of arguments and the credibility of the source are crucial factors influencing persuasion in the Elaboration Likelihood Model (ELM). Park, Lee and Han (2007) found that the information quality and the quantity of reviews have positive and significant influence on purchasing intention, aligning with the study of Mohammad, Quoquab and Mohamed Sadom (2021) which demonstrated that eWOM has a significant effect on consumption.

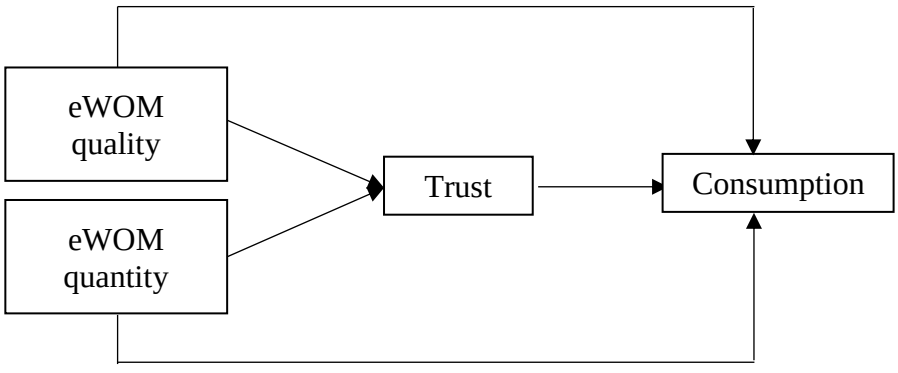
The findings of Kim, Xu and Koh (2004) indicate that Information quality has significant influence on user trust in commercial websites Shankar, Jebarajakirthy, and Ashaduzzaman (2020) expanded on these findings, emphasizing that correct information and reviews are also likely to have a positive impact on consumer decision making and a large number of online review will develop trust and in turn lead to product consumption.

Trust

According to Soares, Pinho and Nobre (2012), trust is about believing that the trusted party is reliable and dependable. Trust has been widely studied in online context (Zhou et al., 2016; Kim & Song, 2010 Kim, Xu & Koh, 2004) because trust is found to be a vital component in triggering consumer response (Bao & Wang, 2021). However, physical evidences that form trust are lacking (Kim & Song, 2010) so consumers need to rely on other clues. Information is one of the clues that has drawn much attention over the past years. Ridings, Gefen and Arinze (2002) highlighted the importance of the relation between information and trust. This concept is further examined by Kim and Song (2010) who found that WOM has positive effect on online trust and online trust in turn has positive intention. Chu and Kim (2011) added that consumer-generated content on social media more reliable than brand-generated content or comments from anonymous or unfamiliar sources. Later research, Filieri (2015) explained that high quality information can build consumer trust that can lead to consumer response. This concept is also explained by Teng and Wang (2015), mentioning that the quality information play a pivotal role in fostering consumer trust, which, in turn, significantly impacts their likelihood of making a purchase.

Based on the review of literature, the current study proposes a conceptual model backedby ELM theory as shown in Figure 1.

Conceptual Framwork:



Source: adapted from Shankar, Jebarajakirthy & Ashaduzzaman (2020)

In accordance with the conceptual framework, the hypotheses are formulated as follows:
H1: eWOM quality has a significant effect on trust
H2: eWOM quantity has a significant effect on trust
H3: eWOM quality has a significant effect on consumption
H4: eWOM quantity has a significant effect on consumption
H5: Trust has a significant effect on consumption

DATA AND METHODOLOGY

The theoretical foundation of the current study lies in the ELM theory. With the objective to investigate the impact of eWOM on consumption, this study collected data online and use convenience sampling approach to administer surveys as this method are widely applied in consumer research (Hair, Page & Brunsveld, 2019). The scale of the study was developed based on validated scales created by former researchers. However, some minor revisions were done to suit the context of this study. The survey instrument was divided into third parts. The first part consists screening questions such as "Are you living in Bangkok?" or "Do you use social media?" The second part consists of demographic questions such as gender, age, education, etc. The third part contained questions related to the various constructs of the study. eWOM quality was measured by four items validated by Filieri (2015) and Anubha (2021). eWOM quantity was measured three items from the study of Anubha (2021). Consumption was measured using items adapted from Kalin (2021). The items were measured using multiple choice and a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

This research focused on regular social media users aged 18 to 45, living in Bangkok, who consume dietary supplements on a regular basis. To determine an appropriate sample size, the Yamane formula was used, resulting in a total of 400 respondents. Before collecting the main data, a pilot test was conducted on 50 respondents using a convenience sampling method. This pilot test assessed the clarity and reliability of the research instrument. After gathering data from 400 participants, the analysis was conducted using the two-step procedure outlined by Anderson and Gerbing (1988). First, a confirmatory factor analysis (CFA) was performed to determine if the measurement variables accurately reflected the hypothesized latent constructs. Subsequently, a structural equation modeling (SEM) analysis was conducted to verify the research hypotheses.

RESULTS AND DISCUSSION

Descriptive statistics of demographic characteristics, behavior and variables are presented in Table 1 and 2**.**

Table 1 – Descriptive statistics of demographic characteristics and behavior (n=400)

Demographics		Frequency	Valid Percent	Cumulative Percent
Gender	Male	155	38.8	38.8
	Female	245	61.3	100.0

Age	18-24	45	11.25	11.25
	25-35	302	75.5	86.75
	36-45	53	13.25	100
Education	Bachelor's degree	307	76.75	76.75
	Master's degree	79	19.75	96.5
	Ph.D	5	1.25	97.75
	High school diploma	7	1.75	99.5
	University diploma	2	0.5	100.0
Income	Lesser than 10000 Baht	10	2.5	2.5
	10000 – 19999 Baht	34	8.5	11
	20000 – 29999 Baht	238	59.5	70.5
	30000 – 39999 Baht	52	13	83.5
	More than 40000 Baht	66	16.5	100
Average consumption of dietary supplement per week	1 – 2 times	172	43	43
	3 – 4 times	161	40.25	83.25
	4 – 5 times	40	10	93.25
	More than 5 times	27	6.75	100

Table 2 – Descriptive statistics of independent and dependent variables (n=400)

Latent variable	Observed variables	Min	Max	Mean	Std. Deviation
eWOM Quality	The information is relevant	1.00	5.00	3.43	1.36
	The information is up-to-date	1.00	5.00	3.44	1.39
	The information is accurate	1.00	5.00	3.43	1.35
	The information covers your need	1.00	5.00	3.36	1.36
	The information is useful	1.00	5.00	3.40	1.37
eWOM quantity	There is a large amount of information on about dietary supplement	1.00	5.00	3.40	1.34
	A large number of consumers write eWOM on dietary supplement	1.00	5.00	3.45	1.30
	The quantity of information was sufficient to satisfy my needs	1.00	5.00	3.50	1.36
	The information on dietary supplement is complete	1.00	5.00	3.34	1.34
Trust	The information is dependable	1.00	5.00	3.36	1.36
	The information is reliable	1.00	5.00	3.45	1.34
	The information is honest	1.00	5.00	3.40	1.35
	The information is sincere	1.00	5.00	3.43	1.37
	The information is trustworthy	1.00	5.00	3.40	1.35
Consumption	I intend to consume dietary supplement in the future	1.00	5.00	3.32	1.27
	I expect I would consume dietary supplement in the future	1.00	5.00	3.54	1.35
	I plan to consume dietary supplement in the future	1.00	5.00	3.47	1.38
	I will make an effort to consume dietary supplement in the future	1.00	5.00	3.40	1.37

Validity and reliability test

This study conducted a measurement model before conducting structural equation modeling (SEM). Confirmatory factor analysis (CFA) was used for the measurement model. Before testing the hypotheses, it is essential to test the discriminant validity and the instrument's reliability. The discriminant validity was tested using the square root of Average Variance Extracted (AVE) of the variables. According to Hair et al. (2019), all the factor loadings are above 0.50 and the average variance extracted (AVE) values should be above 0.50. Cheung, Lee and Rabjohn (2008) added that the square root of AVE for each construct should be greater than the correlations between them and all other constructs to provide evidence of discriminant validity. The instrument's reliability was measured using Cronbach's alpha coefficient and composite reliability (CR), whose should be above 0.7 (Hair et al., 2019).

According to Table 5, the Cronbach's Alpha values and composite reliability of the constructs all meet the satisfactory level of reliability of 0.7. Furthermore, the AVE test results fall above the recommended value of 0.5 and the square root of AVE of each variable is higher than other correlations. Table 6 showed that the factor loading of the items range from 0.876 to 0.914, confirming the convergent validity. Considering all these results, the reliability and the validity are reached.

Table 5 – Measurement model results

	Cronbach alpha	**CR**	**AVE**	**MSV**	**Max R(H)**	**Quality**	**Quantity**	**Trust**	**Adoption**
Quality	0.957	0.959	**0.815**	1.091	0.957	**0.903**			
Quantity	0.94	0.947	**0.797**	1.114	0.94	0.443	**0.893**		
Trust	0.952	0.962	**0.799**	1.101	0.953	0.515	0.412	**0.894**	
Adoption	0.939	0.958	**0.794**	1.114	0.939	0.554	0.424	0.475	**0.891**

Table 6 – Confirmatory Factor Analysis of the model

Observed Variable	Latent variable	β	B	S.E.	C.R.	P
QLT1	eWOM Quality	0.9	1			
QLT2		0.906	1.033	0.034	30.407	*
QLT3		0.893	0.99	0.034	29.237	*
QLT4		0.911	1.017	0.033	30.792	*
QLT5		0.904	1.012	0.034	30.16	*
QNT1	eWOM Quantity	0.891	1			
QNT2		0.905	0.989	0.033	30.048	*
QNT3		0.886	1.014	0.035	28.648	*
QNT4		0.889	0.999	0.035	28.834	*
TRU1	Trust	0.876	1			
TRU2		0.89	1.003	0.036	27.489	*
TRU3		0.913	1.034	0.036	29.08	*
TRU4		0.914	1.05	0.036	29.189	*

TRU5		0.876	0.991	0.037	26.558	*
ADO1	adoption	0.878	1			
ADO2		0.9	1.085	0.038	28.609	*
ADO3		0.893	1.104	0.039	28.175	*
ADO4		0.893	1.093	0.039	28.121	*

Notes: *p < 0.01

Goodness of fit Analysis

The goodness of fit of the model is evaluated in accordance to the study of Park, Hyun, Thavisay (2021). In table 7, we see that all the indices reached an acceptable level of fit. Therefore, the model exhibit a good fit and the path model is valid.

Table 7 – Fit indices of the measurement model

Fit indices	Acceptable Threshold Level	Model results
$\chi 2$/df	<3.0	2.921
P-value	p<.01	0.000
Goodness-of-Fit Index (GFI)	>0.9	0.905
Adjusted Goodness-of-Fit Index (AGFI)	>0.8	0.874
Comparative Fit Index(CFI)	>0.9	0.980
Normed-Fit Index (NFI)	>0.9	0.970
Incremental Fit Index (IFI)	>0.9	0.980
Root Mean Square Residual (RMR)	<0.05	0.032
Root Mean Square Error of Approximation (RMSEA)	<0.08	0.069
SRMR	<0.08	0.0177

Notes: Acceptable Threshold Level based on Park et al. (2021) and Hair et al. (2019)

Table 8 – Structural model results

Hypotheses	Paths	Path estimate (β)	t	P value	Results
H1	eWOM Quality -> Trust	0.685	0.03	*	Supported
H2	eWOM Quantity -> Trust	0.334	0.024	*	Supported
H3	eWOM Quality -> Consumption	0.406	0.023	*	Supported
H4	eWOM Quantity -> Consumption	0.268	0.015	*	Supported
H5	Trust -> Consumption	0.347	0.021	*	Supported

Notes: * < 0.01

CONCLUSION

The Thai dietary supplement market is growing steadily, driven by factors like increased health awareness and aging population (Malaniyom, 2024; Nation Thailand, 2023). Thus, understanding what drives consumers to purchase dietary supplement is essential for companies in this competitive market. Additionally, the influence of digital technology has led to significant shifts in consumer behavior. Consequently, marketers need to explore online behavior to get a better understanding of consumer behavior.

In order to understand better the drivers of consumption of dietary supplement, this study examined the relationship between the variable eWOM, Trust and Consumption. The

results indicate that both the quantity and quality of eWOM have a substantial influence on trust and also on consumption. This findings align with the study of Shankar et al. (2020) and Filieri (2015) showing that online review will develop trust and in turn lead to product usage. Additionally, the study revealed a significant relationship between trust and consumption. This finding is consistent with Bao and Wang's (2021) assertion that trust is a fundamental element in driving consumer responses.

Limitation and recommendations

While this study provides valuable information, its limitations lie in its general approach to dietary supplements and its focus on eWOM and trust as drivers of consumption. Nevertheless, these limitations can be explored further in the future. First, future research could delve deeper into consumer behavior for specific types of dietary supplements such as vitamins, collagen, zinc, etc. Secondly, additional variables like price, promotions, influencers, family, friends, physicians and advertising should be examined in future studies to obtain a more comprehensive perspective on consumer behavior.

REFERENCES

Anubha. (2021). Mediating role of attitude in halal cosmetics purchase intention: an ELM perspective. *Journal Of Islamic Marketing, 14*(3), 645-679.

Bao, Z., & Wang, D. (2021). Examining consumer participation on brand microblogs in China: perspectives from elaboration likelihood model, commitment–trust theory and social presence. *Journal Of Research In Interactive Marketing, 15*(1), 10-29.

Bhattacherjee, A., & Sanford, C. (2006). Influence Processes for Information Technology Acceptance: An Elaboration Likelihood Model. *MIS Quarterly, 30*(4), 805–825.

Buchanan L, Kelly B & Yeatman H (2017). Exposure to digital marketing enhances young adults' interest in energy drinks: An exploratory investigation. *PLoS ONE 12*(2).

Chan, Y.Y. & Ngai, E.W. (2011). Conceptualising electronic word of mouth activity: an input-process-output perspective. *Market. Intell. Plan. 29* (5), 488–516.

Cheung, C.M.K. & Lee, M.K.O. (2012). What drives consumers to spread electronic word of mouth in online consumer-opinion platforms? *Decision Support Systems 53*(1), 218–225.

Cheung, C.M.K., Lee, M.K.O. & Rabjohn, N. (2008). The impact of electronic word-of-mouth: The adoption of online opinions in online customer communities. *Internet Research, 18*(3), 229-247.

Cheung, C. M. K., & Thadani, D. R. (2012). The impact of electronic word-of-mouth communication: A literature analysis and integrative model. *Decision Support Systems, 54*(1), 461–470.

Chou, S., Chen, C.-W. & Shen, Z.-L. (2024). Examining the impact of pharmacist professionalism and celebrity endorsers on dietary supplement purchase intention: the moderating role of product knowledge. *International Journal of Pharmaceutical and Healthcare Marketing, ahead-of-print,* ahead-of-print.

Chu, S., & Kim, Y. (2011). Determinants of consumer engagement in electronic word-of-mouth (eWOM) in social networking sites. *International Journal Of Advertising, 30*(1), 47-75.

Daowd, A., Hasan, R., Eldabi, T., Rafi-ul-Shan, P., Cao, D., & Kasemsarn, N. (2020). Factors affecting eWOM credibility, information adoption and purchase intention on Generation Y: a case from Thailand. *Journal Of Enterprise Information Management, 34*(3), 838-859.

Filieri, R. (2015). Why do travelers trust TripAdvisor? Antecedents of trust towards consumer-generated media and its influence on recommendation adoption and word of mouth. *Tourism Management, 51*, 174-185.

Hair, J., Page, M., & Brunsveld, N. (2019). Essentials of business research methods (4th ed.). New York: Routledge.

Hennig-Thurau, T., Gwinner, K.P., Walsh, G. & Gremler, D.D. (2004). Electronic word-of-mouth via consumer opinion platforms: what motivates consumers to articulate themselves on the internet? *Journal of Interactive Marketing, 18*(1), 38-52.

Kalin, P (2021). Factors Effecting Customer Satisfaction and Purchase Intention: A Case Study of High Protein Food Purchase for Weight Control among Young Adults in Thailand. *Songklanakarin Journal of Management Sciences, 38*(1), 28-55.

Kim, H., & Song, J. (2010). The quality of word-of-mouth in the online shopping mall. *Journal of Research in Interactive Marketing, 4*(4), 376–390.

Kim, H., Xu, Y., & Koh, J. A. (2004). A comparison of online trust building factors between potential customers and repeat customers. *Journal of the Association for Information Systems, 5*(10), 392e420.

Malaniyom, D. (2024). Thai consumers seek overall well-being and immune support in the supplement market. Retrieved 22 August 2024, from https://www.kantar.com/inspiration/fmcg/thai-consumers-seek-overall-well-being-and-immune-support-in-the-supplement-market

Mohammad, J., Quoquab, F. & Mohamed Sadom, N.Z. (2021). Mindful consumption of second-hand clothing: the role of eWOM, attitude and consumer engagement. *Journal of Fashion Marketing and Management, 25*(3), 482-510.

Nation Thailand. (2023). To turn Thailand into Asia's No. 1 health hub. Retrieved 28 August 2024, from https://www.nationthailand.com/pr-news/more/pr-news/40031218.

Park, D., Lee, J., & Han, I. (2007). The Effect of On-Line Consumer Reviews on Consumer Purchasing Intention: The Moderating Role of Involvement. *International Journal Of Electronic Commerce, 11*(4), 125-148.

Park, J., Hyun, H. & Thavisay, T. (2021). A study of antecedents and outcomes of social media WOM towards luxury brand purchase intention. *Journal of Retailing and Consumer Services, 58*,10227.

Petty, R.E. & Cacioppo, J.T. (1986). The Elaboration Likelihood Model of Persuasion. In: Communication and Persuasion. Springer Series in Social Psychology. New York: Springer.

Ridings, C., Gefen, D., & Arinze, B. (2002). Some antecedents and effects of trust in virtual communities. *Journal of Strategic Information Systems,11*, 271–295.

Shankar, A., Jebarajakirthy, C., & Ashaduzzaman, M. (2020). How do electronic word of mouth practices contribute to mobile banking adoption? *Journal Of Retailing And Consumer Services*, 52, 101920.

Soares, A.M., Pinho, J.C. & Nobre, H. (2012). From social to marketing interactions: the role of social networks. *Journal of Transnational Management, 17*(1), 45-62.

Teng, C.-C. & Wang, Y.-M. (2015). Decisional factors driving organic food consumption: Generation of consumer purchase intentions. *British Food Journal, 117*(3), 1066-1081.

U.S. Food and Drug Administration (2022). Questions and Answers on Dietary Supplements. Retrieved 15 August 2024, from https://www.fda.gov/food/information-consumers-using-dietary-supplements/questions-and-answers-dietary-supplements.

Yusuf, A., Che Hussin, A., & Busalim, A. (2018). Influence of e-WOM engagement on consumer purchase intention in social commerce. *Journal Of Services Marketing, 32*(4), 493-504.

Zhao, W., Jin, Y. & Karinshak, E. (2023).Building trust and empowering informed decisions: effects of risk disclosure and call to action on young adults responses to dietary supplement advertising. *International Journal of Pharmaceutical and Healthcare Marketing*, *17*(3), 249-264.

Zhou, T., Lu, Y. & Wang, B. (2016). Examining online consumers' initial trust building from an elaboration likelihood model perspective. *Information Systems Frontiers, 18*(2), 265-275.

CAN A COMPREHENSIVE CONCEPTUAL FRAMEWORK UNLOCK EFFECTIVE GEN-AI INTEGRATION IN MALAYSIA, INDONESIA, AND THE PHILIPPINES' EDUCATION?

Analisa Hamdan[A], Abtar Kaur Darshan Singh[B], Jugindar Singh Kartar Singh[C], Murali Raman[D]

ABSTRACT

The rapid integration of Generative Artificial Intelligence (Gen-AI) in education systems across Malaysia, Indonesia, and the Philippines (Maphilindo) underscores the urgent need for a comprehensive conceptual framework to guide its adoption and implementation. Despite the growing interest in AI technologies, there is a significant gap in the existing literature regarding frameworks that adequately address the unique challenges, ethical considerations, and stakeholder dynamics within these diverse educational contexts. This paper aims to bridge this gap by developing a robust conceptual framework that will serve as a guide for the responsible and effective integration of Gen-AI in education. Grounded in Stakeholder Theory, the Concerns-Based Adoption Model (CBAM), and Design Thinking, the framework ensures that the perspectives and concerns of diverse educational stakeholders—such as educators, students, policymakers, and technology providers—are integrated into the adoption process. CBAM facilitates a deeper understanding of stakeholders' concerns and the stages of adoption, while Design Thinking fosters the creation of innovative, human-centered solutions that respond to the real needs of these stakeholders. The framework, developed through a rigorous review and synthesis of existing theoretical and empirical literature, provides actionable strategies for the responsible integration of Gen-AI in education across the ASEAN region. This proposed framework significantly contributes to the literature on educational technology by offering practical guidance for policymakers and educators in navigating the complex challenges of AI integration.

Keywords: *Generative Artificial Intelligence (Gen-AI), Educational Technology, Theoretical Framework, Stakeholder Engagement, ASEAN Region*

[A] *Digital Learning Designer & Lecturer, Digital Learning Hub, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email:analisa@apu.edu.my Orcid: https://orcid.org/0000-0003-4225-129X*

[B] *Professor, Digital Learning Hub, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: abtar@apu.edu.my Orcid: https://orcid.org/0000-0002-0627-8439*

[C] *Associate Professor, School of Business, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia Email: jugindar.singh@apu.edu.my*

[D] *Deputy Vice Chancellor, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia Email: murali@apu.edu.my*

THAILAND'S ECONOMIC STRUCTURAL TRANSFORMATION: WHAT HAPPENS AFTER THE HEALTH CRISIS IS OVER?

Padcharee Phasuk[A], Vikneswaran Manual[B], Hafinaz Hasniyanti Hassan[C]

ABSTRACT

The health crisis from 2016 to 2022 demonstrates the significant impact on Thailand's industries landscape. Therefore, it is crucial to study these structural changes. The objective of this research is (1) to investigate economic structural transformation of Thailand's industrial sectors and (2) to examine industrial sectors linkages and impact on economics before, during, and after the health crisis. The study employs input-output tables from the Asian Development Bank (ADB) for 36 economic sectors, covering the years 2016, 2019, and 2022. All data will undergo rigorous validation to ensure accuracy and relevance. Network analysis will be used to identify relationships between sub-industries within the economic system. To assess economic linkages and the economy-wide impact, the inverse Leontief matrix calculation will be applied to analyze forward- backward linkages and the direct economic multiplier in each sector. The results indicate a shift in secondary industries towards lighter industries. During the health crisis, the wholesale, food, hotel, and financial industries experienced significant growth. In the post-crisis period, the financial, postal, and retail industries continued to expand, while the hotel industry declined due to decreased aggregate supply and health measures. Moreover, the overall economic multiplier still decreased substantially during the health crisis, averaging 190.01 in 2016, 173.54 in 2019, and 161.05 in 2022 for a one-unit increase in final consumption across all sectors.

Keywords: *Economic Structural Transformation, COVID-19, Network Analysis Model, Thailand*

INTRODUCTION

Economic changes occur all the time to accommodate economic expansion and the direction of national development. The industries need to prepare for unexpected changes. For example, the economic crisis in 1997 or the recent health crisis caused by the COVID- 19 outbreak. The past health crisis from 2016 - 2022 shows the impact on the country's industry. Even though it has clearly had a negative impact, such as the airline industry and accommodation, some industries have expanded, such as transportation, telecommunication, and online industry. Both contraction and expansion causes structural changes to the economy in the industrial level in Thailand which influences the overall economy of the country. However, the negative impact on the economy was largely mitigated by government support

[A] *PhD, Sukhothai Thammathirat Open University, Thailand. Email: padcharee.pha@stou.ac.th*
Orcid: https://orcid.org/0009-0004-7561-8523
[B] *PhD, Asia Pacific University, Kuala Lumpur, Malaysia. Email: vikneswaran.manual@apu.edu.my*
Orcid: https://orcid.org/0000-0003-4924-4391
[C] *PhD, Asia Pacific University, Kuala Lumpur, Malaysia. Email: hafinaz.hasniyanti@apu.edu.my*
Orcid: https://orcid.org/0000-0002-0187-6405

measures for firms and households. Studying the structural changes of various industrial sectors in the economy resulting from the COVID-19 pandemic both before, during and after the pandemic is therefore important in formulating government short-term and long-term measures to mitigate an ongoing aftershock following the health crisis and cope with possible future uncertainties. The objective of this research is to (1) analyze economic structural transformation and (2) examine economic linkages and the economy- wide impact under 3 scenarios which are before, during, and after the health crisis. The remainder of the paper is organized as follows, literatures concerning the structural economic transformation was briefly review, in the next section data and methodology was discussed, then the result and discussion was presented and ending with conclusion and suggestion. The findings of this research would provide a valuable insight into the mechanism of the shift in structural economic due to the profounding effect of the health crisis and to serve as a guideline in formulating policies for economic development to cope with unexpected crises that may occur in the future.

LITERATURE REVIEW

The COVID-19 health crisis has a profound impact upon global economics structure due to the demand shift away from one that requires people to be in near proximity to the activity that can be conducted remotely without face-to-face contact. The early attempt to estimate the impact of the crisis on world's real GDP by Gagnon, Kamin, and Kearns (2023) revealed that the lockdown measure had significant negative impact on the percentage change of GDP in 2020-2021. Agree with Maliszewska, Mattoo, and Van Der Mensbrugghe (2020) which expected the global GDP to decline by 2.1%, while developing countries' GDP is expected to decline by 2.5% and high-income countries by 1.9%. The impact on global economic structure of the COVID-19 pandemic may be broadly explained by the OECD report in 2022, (Arriola, Kowalski, & van Tongeren, 2022) aimed to establish a post COVID- 19 economic baseline, which indicated that the main cause of the global decline in 2020 was the change in consumer demand and labor productivity toward product and service that accommodate working and entertaining from home. The report also pointed out some factors that reenforced each other in some sectors while diminishing others in different sectors. Examples of study and main findings in the shift of economic structure across global economy include the study by Han (2022) in China also indicated deceleration in petroleum and finance industries growth, whereas digital services and scientific research industries experience rapid growth after the health crisis. Similarly, an interesting report by Hensher, Beck, and Nelson (2024) shows evidence of long-term changing landscape in land transport sector due to remote working.

Many sources suggest the long term change in economic structure such as labor skill (Mattana, Smeets, & Warzynski, 2020), a move toword carbon neutral energy consumption (Yang, Hao, & Irfan, 2021), forced digital economics (Ganichev & Koshovets, 2021), and a necessity of structural reform, new technology and re-intregration for economic recovery (Song & Zhou, 2020). All the evidents support the assumption of the impact of COVID-19 on long-term structural economic shift in varying degree across countries. Our result also suggest that main industries of the country i.e., the basic fabricated metal industries remain the important driving force of Thai economy while there are shift in secondary industry in every studied scenario include food, beverage, and tobacco industries, retail industry (except automobiles) and household repairs and wholesale industry and commission trading which agree with the finding from Han (2022).

DATA AND METHODOLOGY

This research employs the input-output table of 36 economic sectors, a secondary dataset provided by the Asian Development Bank (ADB). The analysis spans the years 2016 (2 years before the health crisis), 2019 (during the health crisis), and 2022 (2 years after the health crisis), strategically selected to capture the distinct phases of economic transformation. To ensure data integrity, all retrieved information will undergo rigorous validation, including checks for missing values, relevance, completeness and accuracy. Irrelevant fields will be discarded to prepare a robust dataset for empirical analysis.

To answer the research objectives, the researcher has planned data analysis using the Network Analysis Model to find relationships between sub-industries within the economic system. The results of the change will be reflected through the weight value within the network (Network Weight Degree) together with comparative statistics by testing the difference in means through the t-test between the specified scenario. In Network Analysis Model or Social Network analysis (SNA), the data generated from many of the real-world applications are represented as a network of interconnected objects. The main objective is to extract more information than the traditional way of investigating independent objects. SNA methods and techniques were thus designed to discover patterns of interaction between social actors in social networks. (Tabassum, Pereira, Fernandes, & Gama, 2018)

Regarding the purpose of this paper, there are two major parts of the investigation: (1) economic structural transformation and (2) economic linkage and impact.

Economic Structural Transformation

To capture the structural transformation of the economy, network analysis is employed to illustrate the connections between each economic sector or industry's harmonization. The network weight degree is then quantified by using the average connection among the units, which can be expressed as:

$$EST_t = \frac{1}{n}\sum_{i=1}^{I}\sum_{j=1}^{J} W_{ijt} \qquad ; I \neq 0, J \neq 0$$

Where EST_t is the average weight degree of the economic system, W_{ijt} is the weight degree of each economic sector, and n is the total number of sectors in the economic system. To determine if there is a significant change in the economic system, comparative statistics, such as a paired samples t-test, are employed to assess the mean differences from year to year.

Economic Linkage and Impact

To provide detailed insights into economic transformation, forward-backward linkage computation is applied to indicate the position changes of economic sectors. On one hand, if the forward-linkage index is greater than the backward-linkage index, it means that the sector is involved in upstream activities which is closed to producer. On the other hand, if the forward-linkage index is less than the backward-linkage index, it indicates that the sector is engaged in downstream activities which is closed to consumer. This implies that if a sector increases its production, it will affect all related activities. In particular, the downstream sectors will need to produce more raw materials or intermediate products to meet the expanding demand.

The linkage index can be captured through the input-output table after it is transformed into a Leontief inverse matrix, as follows:

$$Forward\ Linkage\ Index_i = \frac{\sum_j \chi_{ij}}{\frac{1}{n}\sum_i \sum_j \chi_{ij}}$$

$$Forward\ Linkage\ Index_i = \frac{\sum_j \chi_{ij}}{\frac{1}{n}\sum_i \sum_j \chi_{ij}}$$

Where χ_{ij} is the vector of the sector in the economic system, and n is the total number of sectors in the economic system. Additionally, the Leontief inverse matrix can be applied to trace the economy-wide impact if there is an incremental increase in the final demand of a particular sector by one unit, which can be computed using the following formulas:

$$Economic\ Impact_i = diag\left(\sum_j \chi_{ij}\right)$$

where χ_{ij} is the vector of the sector in the economic system, $diag$ refers to the diagonal matrix, and $offdiag$ refers to the off-diagonal matrix.

RESULTS AND DISCUSSION

Economic Structural Transformation

The results of Network Analysis indicated that the Thai economic system has undergone structural transformation after the health crisis with statistical significance. In 2016, the economic connection has a weighted average of all industries at 771.711 and tends to increase. during the health crisis of 2019, with a weighted average of all industries at 847.504 or an increase of 9.821 percent. While after the health crisis in 2022, the weight average of all industries decreased to 688.295 or a decrease of 18.786 percent as shown in Table 1 Figure 1 Figure 2 and Figure 3

Table 1 – Comparison of economic structural changes across time horizons

		Average Weight Degree	% Change	t-test	% Change	t-test
Economic in Thailand in	2016	771.711	9.821	1.316ns		
Economic in Thailand in	2019	847.504				
Economic in Thailand in	2022	688.295			-18.786	4.833***

Note: *** denote statistically significant at 0.01 and ns denote non-significant

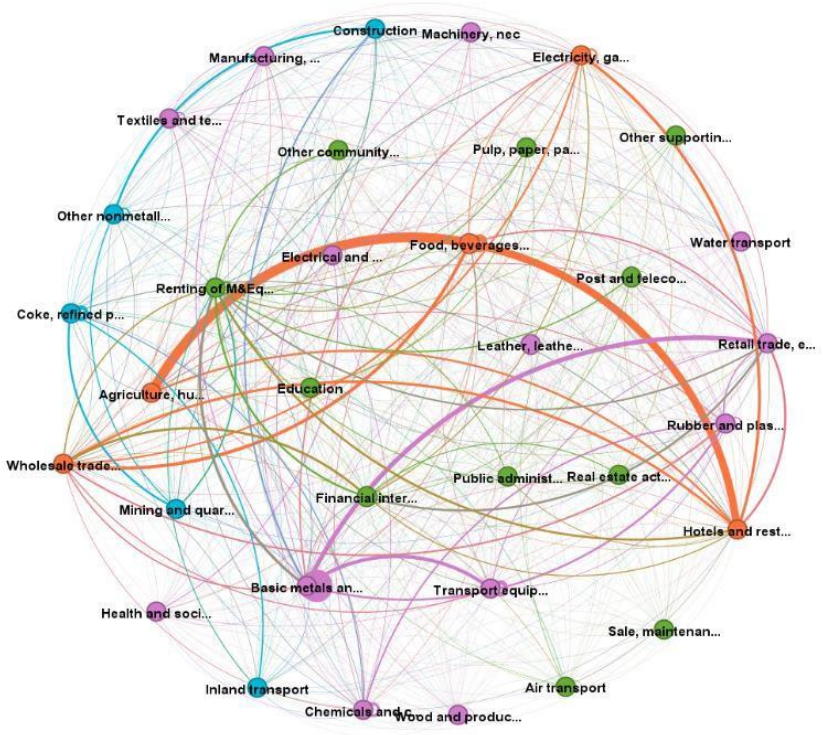


Figure 1 – Thai industrial network analysis model before health crisis (2016)

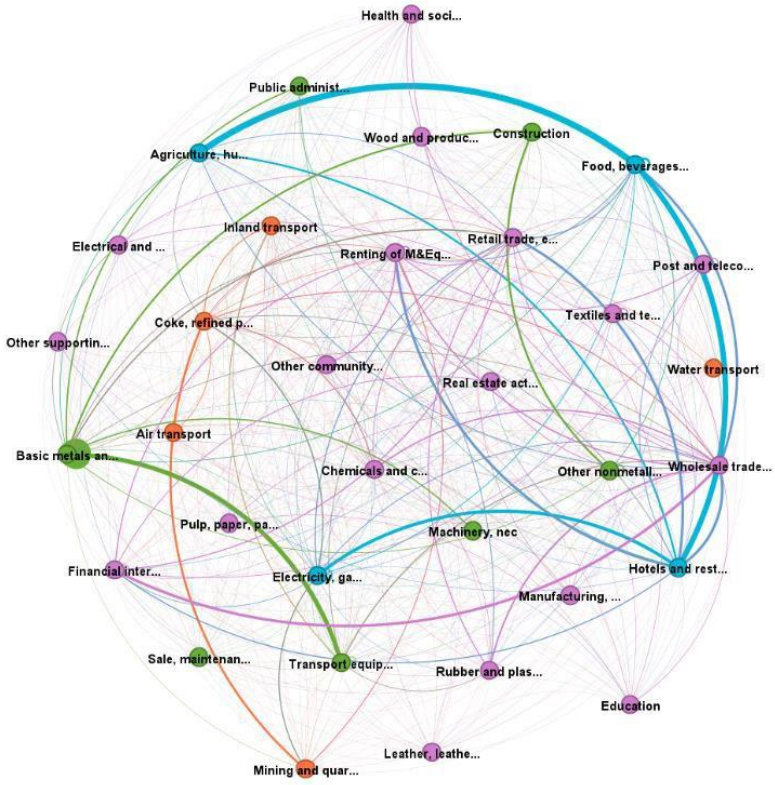


Figure 2 – Thai industrial network analysis model during health crisis (2019)

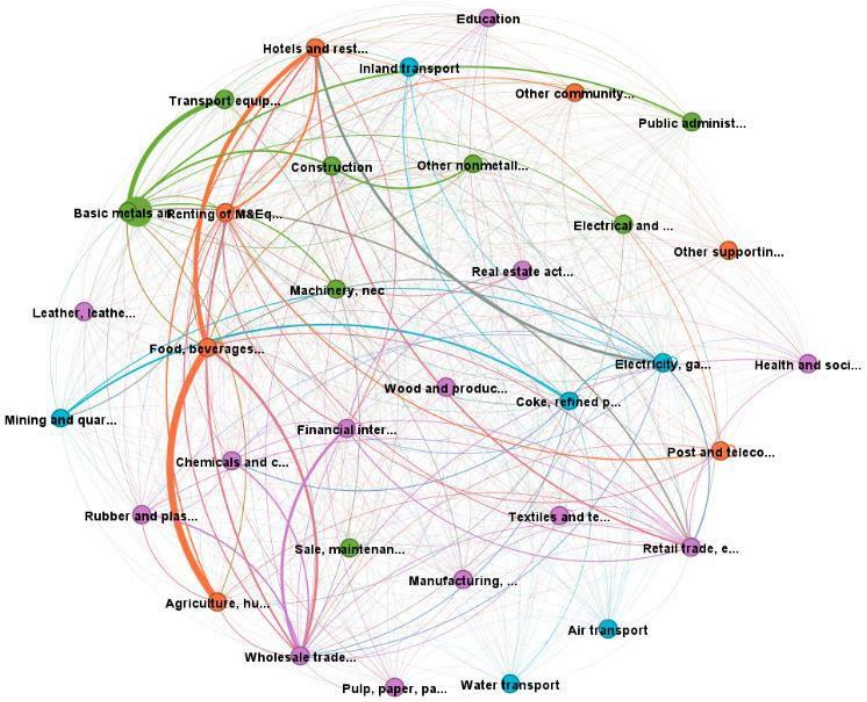


Figure 3 – Thai industrial network analysis model after health crisis (2022)

Weight degree is the density of input value average from every industrial sectors. The thick line in network diagram represent the high-relationship complementing sectors with shared value in economic system.

Considering the connections of industries in the economy in all three scenario, it is found that the main industries of the country i.e., the basic fabricated metal industries and the machinery and equipment rental industry, remain an important cog in driving the Thai economy.

However, this research found that the country's secondary industries have changed in every scenario studied. In 2016, the economic system was driven by 1) Food, beverage, and tobacco industries 2) Retail industry (except automobiles) and household repairs 3) Water, electricity, gas supply 4) Wholesale industry and commission trading (except automobiles), 5) the financial industry, 6) Agriculture, forestry, hunting and fishing industry, Transportation equipment industry, and 8) Hotel and restaurant industry.

The structure of secondary industries in 2016 is not much different from 2019, with the economy being driven by 1) Wholesale industry and commission trade; (except automobiles) 2) Food industry, beverages, tobacco 3) Water, electricity, gas supply 4) Retail industry (except automobiles) and household repairs 5) Agriculture, forestry, hunting and fishing industries 6) Hotel and restaurant industry, 7) Refinery and fuel industry, and 8) Financial industry.

After the health crisis, the structure of the secondary industry apparently changed. The economic system is driven by 1) Wholesale industry and commission trade. (except automobiles) 2) Food, beverage, tobacco industries 3) Water, electricity, gas supply 4) Agriculture, forestry, hunting and fishing industries 5) Retail industries (except automobiles) and household appliance repair 6) Financial industry, 7) Hotel and restaurant industry, and 8) Postal service and telecommunications industry as shown in Table **2**.

Table 2 – Weight of top 10 industry within the network across timeline

Input-Output Decomposition	2016		2019		2022	
	Weight Degree	Rank	Weight Degree	Rank	Weight Degree	Rank
Agriculture, hunting, forestry, and fishing	1199.045	8	1598.491	7	1411.493	6
Food, beverages, and tobacco	1767.338	3	1958.775	4	1731.851	4
Coke, refined petroleum, and nuclear fuel	872.460	12	1112.611	9	696.926	11
Basic metals and fabricated metals	4188.747	1	5005.908	1	4491.643	1
Transport equipment	1080.361	9	688.763	15	365.879	16
Electricity, gas, and water supply	1412.621	5	1735.954	5	1414.996	5
Wholesale trade and commission trade, except of motor vehicles and motorcycles	1385.230	6	2417.101	3	1906.812	3
Retail trade, except of motor vehicles and motorcycles; repair of household goods	1531.558	4	1717.827	6	1234.384	7
Hotels and restaurants	928.451	10	1596.553	8	953.312	9
Post and telecommunications	608.867	15	732.617	12	837.347	10
Financial intermediation	1239.552	7	962.786	10	963.082	8
Renting of M&Eq and other business activities	2020.742	2	2730.619	2	2338.872	2

Economic Linkage and Impact of Each Industrial Sector

Result of the industrial sector economic linkage and impact analysis was shown in and Table 3 and Table 4.

Table 3 – Backward and forward linkage analysis of top 10 industrial sector across timeline

Industrial Sector	2016		2019		2022	
	Rank		Rank		Rank	
Basic metals and fabricated metal	2	Upstream	1	Upstream	1	Upstream
Renting of M&Eq and other business activities	1	Upstream	3	Upstream	2	Upstream
Wholesale trade and commission trade, except of motor vehicles and motorcycles	4	Upstream	2	Upstream	3	Upstream
Electricity, gas, and water supply	7	Upstream	7	Upstream	4	Upstream
Financial intermediation	5	Upstream	6	Upstream	5	Upstream
Coke, refined petroleum, and nuclear fuel	6	Upstream	4	Upstream	6	Upstream
Retail trade, except of motor vehicles and motorcycles; repair of household goods	3	Upstream	5	Upstream	7	Upstream
Post and telecommunications	18	Downstream	9	Upstream	8	Upstream
Agriculture, hunting, forestry, and fishing	10	Upstream	10	Upstream	9	Upstream
Hotels and restaurants	13	Downstream	8	Upstream	10	Downstream
Chemicals and chemical products	8	Upstream	21	Downstream	20	Downstream
Rubber and plastics	9	Upstream	15	Downstream	14	Downstream

The results of input-output analysis in Table 4 show that the mainstream industries include metal, renting machine and equipment and wholesale remain upstream and remain in the upper rank in all cases studied. While secondary industries, that is post and telecommunication shift from downstream before the health crisis to upstream later during and after the health crisis and gone up in rank from 18 before the crisis to 9 after the crisis. The transformation in post and telecommunications, which comprise online delivery platforms such as Grab experienced rapid expansion during and after the lockdown. While the chemical and

rubber and plastic product sector, which primarily engages in upstream activities, experienced decline during the crisis and shifted more toward consumer-side activities after the crisis.

Table 4 – Economic impact analysis of top 10 industrial sector across timeline

Industrial Sector	2016		2019		2022	
	Impact	Rank	Impact	Rank	Impact	Rank
Basic metals and fabricated metal	413.49	2	605.25	1	546.76	1
Renting of M&Eq and other business activities	445.00	1	329.63	3	321.68	2
Wholesale trade and commission trade, except of motor vehicles and motorcycles	310.67	4	353.16	2	303.55	3
Electricity, gas, and water supply	279.35	7	257.44	7	249.32	4
Financial intermediation	306.03	5	263.14	6	247.59	5
Coke, refined petroleum, and nuclear fuel	305.40	6	293.77	4	234.36	6
Retail trade, except of motor vehicles and motorcycles; repair of household goods	312.46	3	279.70	5	233.92	7
Post and telecommunications	155.02	18	191.32	9	204.10	8
Agriculture, hunting, forestry, and fishing	206.08	10	181.70	10	171.22	9
Hotels and restaurants	188.59	13	201.11	8	158.68	10
Chemicals and chemical products	264.92	8	122.11	21	120.57	20
Rubber and plastics	214.51	9	156.20	15	139.19	14
Average (all 34 sectors)	190.01		173.54		161.05	

The result in Table 4 show the economic multiplier or the change in value of each industrial sector by change in aggregate demand. The primary industrial sector includes metals, renting machine and equipment and wholesale experience negative impact from the health crisis but remain the main driving force of Thai economic in both before and after the crisis. Chemical and rubber and plastic products experienced a drop in value during and after the crisis from 264.92 and 214.51 respectively in 2016 to 120.57 and 139.19 respectively in 2022. Post and telecommunications experienced an increase in economic multiplier from 155.02 in 2016 to 191.32 in 2019 and continued to 204.10 in 2022. In contrast, hotel and restaurant faced reduction in value from 188.59 in 2016 and 201.11 in 2019 to 158.68 in 2022. While there is an increase in value of post and telecommunications resulting from the shift in work-from-home norm, the average overall impact for all 34 industrial sectors substantially reduced from 190.01 before the crisis to 173.54 during the crisis and 161.05 after the crisis due to the prolonged impact of lockdown and global economic recession afterward.

Our result agree with finding from Han (2022) which indicates that petroleum and finance industries faced deceleration in growth, whereas digital services and scientific research industries experience rapid growth after the health crisis. Evidents support the substantially increase in IT used after the COVID-19 pandemic was reviewed in Battisti, Alfiero, and Leonidou (2022). Also Mattana et al. (2020) emphasized the impact of COVID- 19 on the structural transitions in the economy include the need in skilled labor.

CONCLUSION

The research concluded that the structure of the Thai industrial system has undergone significant changes after the health crisis. In particular, the country's secondary industries have changed throughout the scenario studied. The results indicate that the trend of secondary industries has shifted towards more light industry. During the health crisis, the wholesale industry, food industry, hotel Industry and financial industry has been remarkably increasing. In the period after the health crisis financial industry postal service and retail industry undergo rapid growth. Meanwhile, the hotel industry is in decline due to a decrease in aggregate supply and health measures. Main upstream industries such as metals, renting machine and wholesale still hold the ground in supporting Thai economics indicate the industries resistant to uncertainty while emerging industry such as post and telecommunications saw rapid growth. Some industries have transformed from upstream to downstream to get closer to the consumer accommodating the change in demand after the health crisis.

After the crisis, Thailand and many countries in the world have seen the rapid growth in digital economic trend due to the need to reduce face-to-face transaction. AI and other disruptive technology also strengthen the need for economic transformation to survive. Also, the negative impact of work-from-home trend on the financial and psychologicle aspect of employees is rarely discussed as pointed out by Battisti et al. (2022) and should be further investigated.

This is the preliminary analysis focus on the structural change before during and after health crisis of industries in Thailand economics system. The value added to the economic system from emerging sub-economics should be further investigated. Also, Leontief macro model and multipliers should be employed and expanded to analyze in detail the added value of emerging sub industry

REFERENCES

Arriola, C., Kowalski, P., & van Tongeren, F. (2022). Understanding structural effects of COVID-19 on the global economy: first steps.

Battisti, E., Alfiero, S., & Leonidou, E. (2022). Remote working and digital transformation during the COVID-19 pandemic: Economic–financial impacts and psychological drivers for employees. *Journal of Business Research, 150*, 38-50. doi: https://doi.org/10.1016/j.jbusres.2022.06.010

Gagnon, J. E., Kamin, S. B., & Kearns, J. (2023). The impact of the COVID-19 pandemic on global GDP growth. *Journal of the Japanese and International Economies, 68*, 101258. doi: https://doi.org/10.1016/j.jjie.2023.101258

Ganichev, N. A., & Koshovets, O. B. (2021). Forcing the Digital Economy: How will the Structure of Digital Markets Change as a Result of the COVID-19 Pandemic. *Studies on Russian Economic Development, 32*(1), 11-22. doi:10.1134/S1075700721010056
Han, Y. (2022). The impact of the COVID-19 pandemic on China's economic structure: An input–output approach. *Structural Change and Economic Dynamics, 63*, 181-195. doi: https://doi.org/10.1016/j.strueco.2022.09.014

Hensher, D. A., Beck, M. J., & Nelson, J. D. (2024). What have we learned about long-term structural change brought about by COVID-19 and working from home? *Transportation Letters, 16*(7), 738-750. doi: https://doi.org/10.1080/19427867.2023.2237269

Maliszewska, M., Mattoo, A., & Van Der Mensbrugghe, D. (2020). The potential impact of COVID-19 on GDP and trade: A preliminary assessment. *World Bank policy research working paper* (9211).

Mattana, E., Smeets, V., & Warzynski, F. (2020). Changing skill structure and COVID-19. *Covid Economics*, *45*, 1-30.

Song, L., & Zhou, Y. (2020). The COVID-19 Pandemic and Its Impact on the Global Economy: What Does It Take to Turn Crisis into Opportunity? *China & World Economy*, *28*(4), 1-25. doi: https://doi.org/10.1111/cwe.12349

Tabassum, S., Pereira, F. S., Fernandes, S., & Gama, J. (2018). Social network analysis: An overview. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *8*(5), e1256.

Yang, C., Hao, Y., & Irfan, M. (2021). Energy consumption structural adjustment and carbon neutrality in the post-COVID-19 era. *Structural Change and Economic Dynamics*, *59*, 442-453. doi: https://doi.org/10.1016/j.strueco.2021.06.017

MONOPOLISTIC INFLUENCE ON POLICY PERFORMANCE: A DSGE APPROACH TO THAILAND'S TECHNOLOGY AND AGRICULTURAL SECTOR ECONOMY

Piyasiri Kongwiriyapisal[A], Adirek Vajrapatkul [B]

ABSTRACT

This research investigates the impact of monopoly power on economic policy performance. The objective is to analyze how monopolistic conditions affect the efficacy of government interventions and technological shocks on economic growth. This study utilizes a dynamic stochastic general equilibrium (DSGE) model and Bayesian estimation techniques with quarterly data from 2002 to 2021 to simulate the model. The results reveal that monopoly power significantly dampens the effectiveness of monetary policy, leading to increased prices and reduced labor demand, which minimally impacts overall economic growth. In contrast, fiscal policy shocks were found to positively influence labor and capital demand, suggesting that effective government spending can mitigate some adverse effects of monopoly power. These findings underscore the complex relationship between market structures and policy outcomes, highlighting the necessity for robust antimonopoly regulations to enhance economic performance. The study contributes valuable insights for policymakers, emphasizing the potential of strategic fiscal interventions to drive growth even in monopolistic environments.

Keywords: *technology sectors, agricultural sectors, monopoly power, DSGE, Thailand*

1. INTRODUCTION

Monopoly power, a firm's ability to influence market prices and output levels, is a significant concern in business and economics due to its potential negative impacts on market efficiency and consumer welfare as it allow producer charge prices above marginal costs. In general, this power is masured by the Lerner Index, introduced by Abba Lerner in 1934 (Elzinga & Mills, 2011). The concept of monopoly power extends beyond traditional market structures to, e.g., international trade (Lundborg, 1984) and public sector (Carroll, 1989).

Monopoly power is a critical concern in economics due to its significant impact on market dynamics and overall economic welfare. Studies have shown that monopoly power can have both positive and negative consequences, making it a complex issue that requires careful consideration.

On one hand, monopoly power can lead to increased innovation and economic growth. Research suggests that higher monopoly profits can attract investments in capital, driving down marginal costs and stimulating economic growth (Branger et al., 2019). Additionally, even

[A] *Ph.D, School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: piyasiri.rua@stou.ac.th*

[B] *Ph.D., School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: a.vajrapatkul@gmail.com, Orcid: https://orcid.org/0000-0002-6348-8977*

workers may prefer firms to have some market power because profit provides incentives for innovation (Chu et al., 2023). In certain cases, monopoly power can also enhance consumer and market welfare by creating incentives for quality improvements (Wisnicki, 2021). However, monopoly power can also have detrimental effects. It can result in poor performance of companies in the long term, leading to waste of national resources and limitation of financial policies (Dai & Guo, 2020). Monopoly power can also inhibit technological progress, particularly when firms engage in rent-seeking behavior instead of investing in research and development (Du et al., 2020). Furthermore, the aggravation of monopoly power can increase production scale without improving product quality, which is unfavorable for long-term economic growth (Yu et al., 2023).

Scholars try to study the levels, causes, and effects of monopoly power by using various methodologies. For instance, A study on oil price shocks proposed a new way to identify markup shocks combining with a general equilibrium model to understand macroeconomic consequences (Branger et al., 2019). research on Chinese energy enterprises utilized micro-data to measure monopoly power, rent-seeking, and technological progress (Du et al., 2020). One study recreated different double-auction market structures in a within-subject design to examine how trading institutions and price anchors affect monopoly power (Attanasi et al., 2021). Recent study used the fair competition review system as a quasi-natural experiment to investigate the relationship between administrative monopoly regulation and green innovation in A-share-listed companies from 2012 to 2022 and discovered that administrative monopoly regulation positively correlates with green innovation (Zhu et al., 2024). Furthermore, Szádoczkiné and Madari (2024) present a different methodological approach to studying monopoly power in the banking sector which allows them to recover that the bank market exhibited characteristics of monopolistic competition during the studied period.

The above knowledge highlights the complexity of monopoly power and the need for further investigations. According to this research domain, it still leaves large room for investigation into the impacts of monopoly power on the economy-wide. This study is motivated by the significant concerns surrounding monopoly power and its implications for economic efficiency and consumer welfare. Despite the established recognition that monopoly power can influence market dynamics, gaps remain in understanding how it affects the efficacy of government policies, particularly in developing economies like Thailand. Previous research has shown mixed results regarding the effects of monopoly power—while it may foster innovation in some contexts, it often leads to inefficiencies and limits the effectiveness of fiscal and monetary policies. This presents a practical challenge for policymakers striving to optimize economic outcomes in the presence of monopolistic market structures. The research seeks to address these unresolved questions by examining the interplay between monopoly power and policy effectiveness, thereby filling critical gaps in the existing literature. To achieve these objectives we organize the remaining of this study as follows. In the next section, the concepts and factors relating to monopoly power will be highlighted. Then a hypothesized economy model will be formulated in Section 3. Section 4 will provide the simulation results. Thereafter we will discuss the result and suggest some policy interventions.

2. LITERATURE REVIEW

Monopoly power describes a firm's capacity to influence market prices and sustain profits above competitive levels, typically due to a lack of competition and market dominance (Elzinga & Mills, 2011). It allows firms to charge prices above marginal costs and maintain market dominance, often through controlling prices, excluding competitors, and influencing market

conditions (Altan, 2020; Branger et al., 2019). Monopoly power enables firms or groups of firms to exert significant control over market prices and output, often resulting in reduced competition and increased market dominance. This power allows firms to influence market conditions to their advantage, potentially leading to higher prices, reduced consumer choice, and inefficiencies in resource allocation.

This concept is vital in various economic frameworks and policy discussions, particularly in trade, public sector, and industrial organization theories. In trade policy models, monopoly power can significantly impact the distributional effects of tariffs and subsidies (Lundborg, 1984).

In international trade, monopoly power can manifest in various forms. For instance, the United States and Australia hold a monopoly on forage trade, demonstrating significant market power in this sector (Wang et al., 2023). However, in the public sector, the assumption of monopoly power suggests that the federal bureaucracy's monopoly structure may be more limited than traditionally assumed (Carroll, 1989). The concept of monopoly power extends to the digital platform economy, where companies like Amazon exert control through data ownership, technology, and global labor fragmentation (Coveri et al., 2022). The ongoing debate about monopoly power in the tech industry, exemplified by the case against Facebook, underscores the challenges in defining and measuring market power in modern economies (Steinbaum, 2022).

Monopoly power can emerge from various sources. Administrative monopolies, granted through government concessions and regulations, can create significant monopoly power. In China's oil and petrochemical industry, barriers to entry, special privileges, and price regulation have led to multi-level monopolistic powers (Yan & Pu, 2014). Increasing returns to scale in data gathering and processing give rise to digital monopolies, posing new challenges for regulators and antitrust authorities (Loertscher & Marx, 2020). This form of monopoly power stems from improved match values and reduced privacy, allowing digital monopolies to extract consumer surplus effectively.Natural monopolies can arise in industries with high fixed costs and economies of scale, such as public utilities (Tschirhart, 1995). However, the presence of monopsony power can bias empirical tests for natural monopoly status, potentially leading to improper policies. Barriers to entry and spatial fragmentation can contribute to monopoly power, as seen in the groundwater market in Pakistan's Punjab region (Jacoby et al., 2004). Monopoly power can also derive from market structure, investment strategies, and institutional factors. Innovations in the oil market, for instance, can lead to increased monopoly power, as demonstrated by OPEC meetings and their ability to charge markups over marginal costs (Branger et al., 2019). Firms can accumulate market power through a process of forward-looking, risky investment in productivity growth (Peters, 2020). In China's energy industry, monopoly power is often maintained through rent-seeking activities, particularly by state-owned enterprises, which can inhibit technological progress (Du et al., 2020). Moreover, information spillovers across products can strengthen big firms' monopoly power by driving them to innovate more strategically and allowing them to raise market entry barriers (Yu et al., 2023). In some cases, technological advancements and product differentiation can lead to monopolistic situations. A study on car-sharing strategies found that manufacturers' decisions to share either gasoline vehicles (GVs) or EVs can impact market dynamics and potentially create monopolistic advantages (Feng et al., 2024). A study on the Romanian electricity market highlighted how various factors, including economic policies, fuel costs, and environmental regulations, shape market dynamics and potentially lead to reduced competition (Georgescu et al., 2024).

In general, it was perceived that monopoly power can negatively affect economic growth and long-term welfare, potentially overshadowing the static losses traditionally

considered in economic literature (Neumann, 1999). For example, in the automobile industry, concentrated market power has led to decision-making distortions, making companies vulnerable to external forces (Kwoka, 1984). In open economies, the impact of monopoly power depends on factors such as market size and product substitutability, potentially leading to welfare losses due to underconsumption and excessive importation (Stegemann, 1984). In the energy sector, monopoly power can lead to rent-seeking behavior, particularly among state-owned enterprises, impeding technological progress and efficient market development (Du et al., 2020). Excessive monopoly power can lead to market distortions and inefficiencies, as observed in China's banking industry (Dai & Guo, 2020). In the energy sector, monopoly power is often associated with rent-seeking behavior, which can inhibit technological progress, particularly in state-owned enterprises (Du et al., 2020). In China's export product market, strengthening inter-product information spillovers has led to increased market share and survival rates for big firms, intensifying monopoly power. However, this aggravated monopoly only increases export scale without improving product quality, which is unfavorable for long-term economic growth (Yu et al., 2023). in the context of renewable energy development in China, competition among utilities tends to benefit renewable energy development, suggesting that monopolistic structures may hinder progress in this sector (Zhao et al., 2023).

However, monopoly power does not always result in negative outcomes or lead to reduced production and higher prices. In some cases, firms may increase production beyond competitive levels to balance current profits with future profit valuations, potentially destroying shareholder value (Basak & Pavlova, 2004). For instance, in a two-country trade model, significant monopoly power combined with increased economic integration can lead to accelerated productivity growth and greater national welfare (Davis & Hashimoto, 2016). In the internet industry, large enterprises benefiting from economies of scale may enhance consumer welfare without necessarily exercising market power (Sun et al., 2017). Additionally, increased monopoly power in oil markets can stimulate global economic activity by attracting investments in oil-producing capital (Branger et al., 2019). Some degree of monopoly power may be beneficial for innovation, as profits provide incentives for innovation, which even workers may prefer (Chu et al., 2023). In the Schumpeterian economy, even workers may prefer firms to have some market power as profit provides incentives for innovation (Chu et al., 2023).

3. THE MODEL

3.1 Households

The representative household in this hypothesized economy seeks to maximize its lifetime utility which is increased by consuming goods while decreased by the working hour. The utility function utilized in this work was adapted from the usual utility function (Alba et al., 2011) (Justiniano & Preston, 2010) (Jääskelä & McKibbin, 2009) which is expressed as follows:

$$E_t \sum_{t=0}^{\infty} \beta^t \left(A_{C,t} \frac{\left(C_{H,t}\right)^{1-\sigma}}{1-\sigma} - A_{L,t} \frac{\left(L_t\right)^{1+\varphi}}{1+\varphi} \right), \quad (1)$$

where the constants β, σ, and φ represent the intertemporal discount factor, the inverse elasticity of consumption, and the inverse elasticity of labour supply. $C_{H,t}$, and L_t are private

goods and household working hour, respectively. $A_{C,t}$ and $A_{L,t}$ denote consumption and labor supply evolution that accounts for anomaly changes (Alp & Elekdag, 2012). This shock follows a first-order autoregressive process expressed by:

$$\ln\left(A_{C,t}\right)=\left(1-\rho_{AC}\right)\ln\left(A_{Css}\right)+\rho_{AC}\ln\left(A_{C,t-1}\right)+\varepsilon_{AC,t}\ ,\ \left|\rho_{AC}\right|<1,\varepsilon_{AC,t}\sim N\left(0,Q_{AC}\right). \qquad (2)$$

In each period, the household derives income from working, renting out capital, and retaining the profit from investment in the domestic firm, and holding bonds. Therefore, the budget constraint of the household can be represented by

$$W_tN_t+R_{K,t}K_t+B_t+\prod_t=P_t\left(C_t+I_t\right)+\frac{B_{t+1}}{R_t}+T_t\ , \qquad (3)$$

where K_t, B_t, $\prod_t$, I_t, and T_t are capital, riskless one-period bonds, profit, investment, and lump-sum tax, respectively. W_t, $R_{K,t}$, and R_t, denote, respectively, the wage, capital rental rate, and policy rate.

The usual law of motion of capital is defined by

$$K_{t+1}=\left(1-\zeta\right)K_t+I_t\ , \qquad (4)$$

where ζ is the capital depreciation rate.

The first-order solutions in the log linearization form of this household problem are given by:

$$\tilde{W}_t=\sigma\tilde{C}_{H,t}+\varphi\tilde{L}_t-\tilde{A}_{C_t}+\tilde{A}_{L_t}+\tilde{P}_t, \qquad (5)$$

$$\left(1+(2\delta-2)\beta\right)R_{X,t+1}=2(\delta-1)\beta\tilde{P}_{t+1}+\tilde{A}_{C,t}-\tilde{C}_{H,t}+\tilde{P}_{t+1}-\tilde{A}_{C,t+1}+\tilde{C}_{H,t+1}, \qquad (6)$$

$$\sigma\left(\tilde{C}_{H,t+1}-\tilde{C}_{H,t}\right)=\left(\tilde{A}_{C,t+1}-\tilde{A}_{C,t}\right)-\left(\tilde{P}_{t+1}-\tilde{P}_t\right)+\tilde{R}_t. \qquad (7)$$

3.2 Intermediate Technological Firms

Technological Firms use Cobb-Douglas technology with capital, labor, and agricualteral output to produce output. This production function is given by:

$$Y_{j,t}=A_{T,t}K_t^{\alpha1}L_t^{\alpha2}Y_{A,t}^{\alpha3}, \qquad (8)$$

where $\alpha_1,\alpha_2,\alpha_3$ are, respectively, the shares of capital, labor, and agricultural output in the production. $A_{T,t}$ and $Y_{A,t}$ are a technology and agricualtral output evolution. To simplify the investigration of the effects of monopoly power, in this study we assume that these evolution follow a first-order autoregressive process.

The first-order solutions in the log linearization form of this firm problem are given by:

$$\tilde{W}_t + \tilde{L}_t = \tilde{P}_t + \tilde{Y}_{j,t}, \tag{9}$$

$$\tilde{R}_{Kt} + \tilde{K}_t = \tilde{P}_t + \tilde{Y}_{j,t}, \tag{10}$$

$$\tilde{P}_{j,t} = -\frac{1}{\alpha_1+\alpha_2}\begin{pmatrix} \left(\frac{1}{A}\right)^{-\frac{\alpha_1}{\alpha_1+\alpha_2}} \begin{pmatrix} -\alpha_1^{-\frac{\alpha_1}{\alpha_1+\alpha_2}}(-\tilde{Y}_t+\tilde{W}_t)\alpha_2^{\frac{2\alpha_1+\alpha_2}{\alpha_1+\alpha_2}} \\ +\begin{pmatrix} \left(\alpha_3\tilde{Y}_{A,t}+\tilde{A}_t-\tilde{W}_t-\tilde{Y}_t\right)\alpha_1^{-\frac{\alpha_1}{\alpha_1+\alpha_2}} \\ -\alpha_1^{\frac{\alpha 2}{\alpha 1+\alpha 2}}\left(\tilde{R}_{K,t}-\tilde{Y}_t+\tilde{W}_t\right) \end{pmatrix}\alpha_2^{\frac{\alpha_1}{\alpha_1+\alpha_2}} \end{pmatrix} \\ A_{ss}^{-\frac{\alpha_1}{\alpha_1+\alpha_2}}\left(\frac{\alpha_2 R_{Kss}}{\alpha_1}\right)^{-\frac{\alpha 1}{\alpha 1+\alpha 2}} R_{Kss}^{\frac{\alpha 1}{\alpha 1+\alpha 2}} \end{pmatrix}. \tag{11}$$

Based on the Calvo rule, it assumes that the firm has a ω probability of keeping the price of its good fixed in the next period and a $(1-\omega)$ probability of optimally defining its price $AP_{j,t}$. The problem of the firms that are capable of readjusting their price is exhibited by:

$$MAX_{AP_{j,t}} E_t \sum_{i=0}^{\infty} (\beta\omega)^i \left(AP_{j,t}Y_{j,t+i} - TC_{j,t+i}\right) \tag{12}$$

The first-order solutions provides that:

$$AP_{j,t} = \frac{\psi_Y}{(\psi_Y - 1)} E_t \sum_{i=0}^{\infty} (\beta\omega)^i MC_{j,t+i}, \tag{13}$$

3.3 Final good firm

The final good Y_t is produced by an aggregator that collects differentiated goods from a continuum of intermediate firm $j \in [0,1]$ using the following Dixit-Stiglitz aggregator (Coibion & Gorodnichenko, 2008):

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{1}{\psi_Y}} dj\right)^{\psi_Y}, \tag{12}$$

where Y_{jt} is the demand for intermediate good j and $\psi_Y > 1$ denotes the producer's monopoly power.

The producer solves the following problem:

$$MAX_{Y_{jt}} P_t Y_t - \int_0^1 P_{j,t} Y_{j,t}\, dj \,. \tag{13}$$

The solutions to the maximization problem of the producer are as follow:

$$Y_{j,t} = Y_t \left(\frac{P_t}{P_{j,t}} \right)^{\frac{\psi_Y}{\psi_Y - 1}} . \tag{14}$$

Further simple manipulation, we have:

$$P_t = \left(\int_0^1 P_{j,t}^{1-\psi_Y} dj \right)^{\frac{1}{1-\psi_Y}} . \tag{15}$$

Using (13), we obtain the following price index

$$P_t = \left(\omega P_{t-1}^{1-\psi_Y} + (1-\omega) A P_{j,t}^{1-\psi_Y} \right)^{\frac{1}{(1-\psi_Y)}} . \tag{16}$$

3.4 Government Authority

The fiscal authority decides on total spending for producing public goods, $C_{G,t}$ by taking into account the previous level of national income (Iwata, 2009) (Bhattarai & Trzeciakiewicz, 2017) and inflation. Therefore the fiscal policy rule can be written in the following form

$$\frac{C_{G,t}}{C_{Gss}} = \left(\frac{C_{G,t-1}}{C_{Gss}} \right)^{\zeta_G} \left(\frac{Y_{ss}}{Y_{t-1}} \frac{\pi_{ss}}{\pi_{t-1}} \right)^{(1-\zeta_G)\kappa_G} A_{G,t} \,, \tag{17}$$

For monetary authority, it was assumed to sets a short-term nominal interest rate, R_t according to a simple rule (Bache et al., 2010) (Pakdeesana, 2015) as follows

$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}} \right)^{\zeta_M} \left(\left(\frac{Y_t}{Y_{ss}} \right)^{\kappa_Y} \left(\frac{\pi_t}{\pi_{ss}} \right)^{\kappa_\pi} \right)^{(1-\zeta_M)} A_{M,t} \,, \tag{18}$$

where $A_{M,t}$ and $A_{G,t}$ denote a monetary and fiscal policy evolution that also follows a first-order autoregressive process. We close this model with the following Market-clearing condition $Y_t = C_{H,t} + C_{G,t} + I_t$.

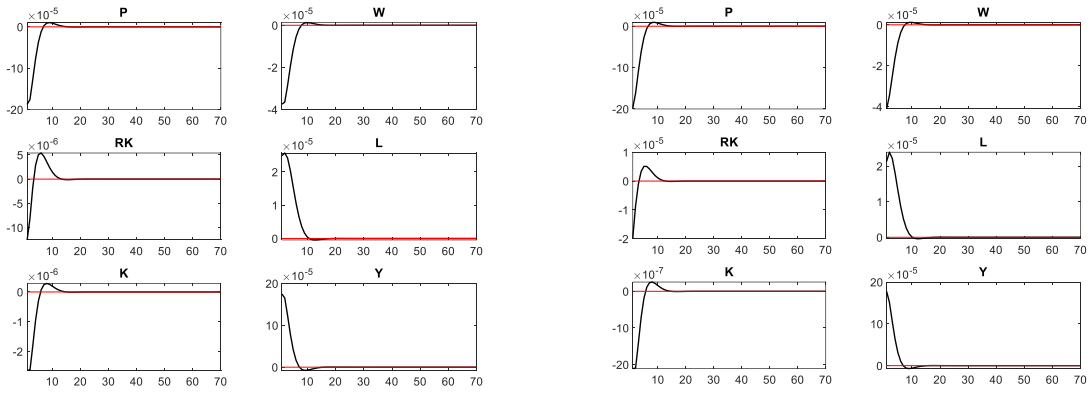
The model is estimated using quarterly data from Thailand which is obtained from The World Bank database which covers the period between 2002:Q1-2021:Q2 including GDP, policy rate, employment, and consumer price index (CPI).

4. RESULTS

In the estimation process, we set $\alpha_1 = 0.5, \alpha_2 = 0.3,$ $\alpha_3 = 0.2$ and $\omega = 0.5$. The estimation results are represented in Table 1 and Figure 2.

Table 1 – Priors and posteriors of model parameters

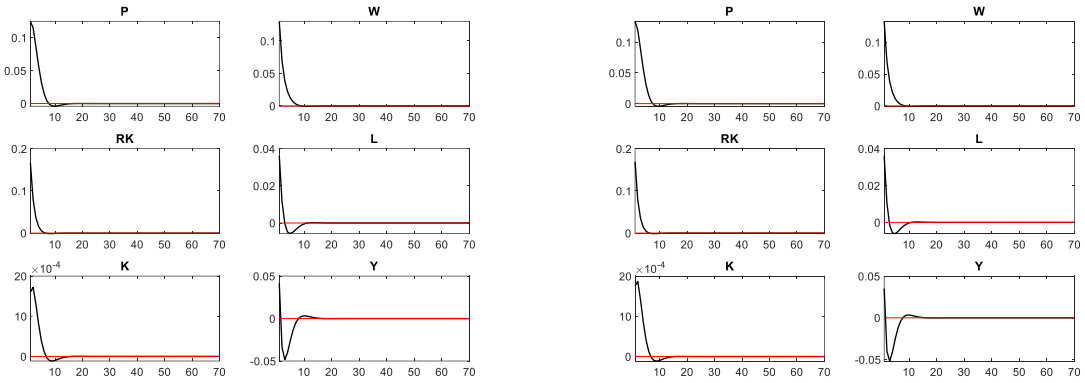
Parameter	prior mean	post. mean	HPD inf	HPD sup
φ	3.000	1.301	2.943	3.142
η	1.000	1.006	0.952	1.095
σ	0.700	0.704	0.690	0.722
β	0.970	0.971	0.969	0.972
δ	0.011	0.007	0.000	0.017
ζ_G	0.200	0.199	0.177	0.217
ζ_M	0.200	0.617	0.534	0.674
κ_G	0.200	0.617	0.534	0.674
κ_π	0.200	0.197	0.184	0.211
κ_Y	0.200	0.202	0.188	0.216



(b) $\psi_Y = 1.001$ (a) $\psi_Y = 1.1$

Figure 1 – Consumption shock

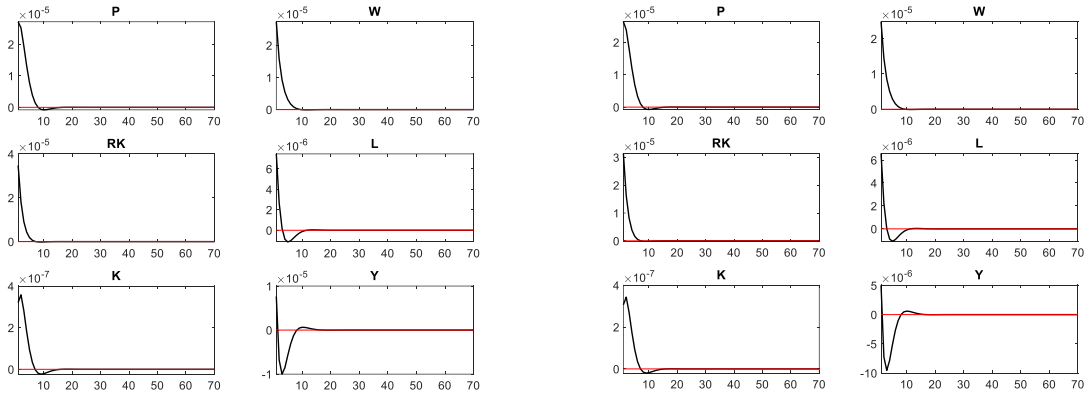
Figure 1 illustrates the effect of a consumption shock on the economy, highlighting the role of monopoly power. The shock causes an increase in the capital rental rate (r), while simultaneously reducing capital demand (K). Despite these changes, the consumption shock does not significantly impact overall economic growth (Y).



(b) $\psi_Y = 1.001$ (a) $\psi_Y = 1.1$

Figure 2 – Technology shock

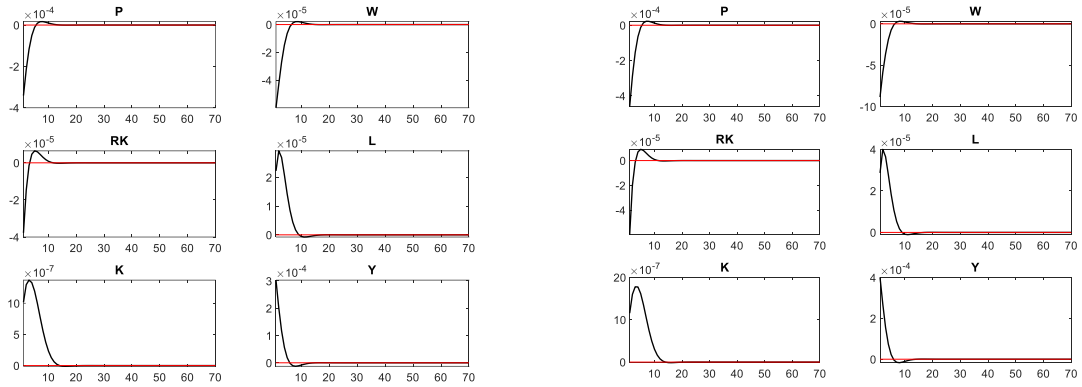
Figure 2 demonstrates the impact of a technology shock on the economy, particularly under the influence of monopoly power. The technology shock slightly reduces the capital rental rate (r) while increasing capital demand (K). However, similar to the consumption shock, the overall effect on economic growth (Y) remains minimal.



(b) $\psi_Y = 1.001$ (a) $\psi_Y = 1.1$

Figure 3 – Agriculture sector shock

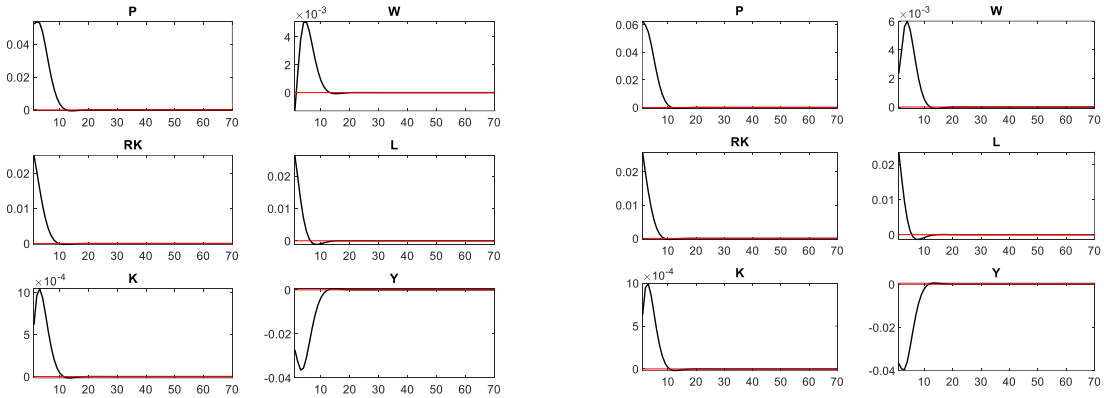
Figure 3 illustrates the effects of an agriculture sector shock on the economy. The shock leads to a slight increase in economic growth (Y), indicating a positive response in this sector.



(b) $\psi_Y = 1.001$ (a) $\psi_Y = 1.1$

Figure 4 – Fiscal policy shock

Figure 4 shows the effects of a fiscal policy shock on the economy, with monopoly power playing a notable role. The shock leads to a decrease in both the wage rate (w) and the capital rental rate (r), which in turn boosts labor demand (L) and capital demand (K). As a result, economic growth (Y) is positively influenced. This suggests that fiscal policy becomes more effective in stimulating labor and capital markets under monopolistic conditions, driving modest economic growth.



(b) $\psi_Y = 1.001$ (a) $\psi_Y = 1.1$

Figure 5 – Monetary Policy Shock

Figure 5 illustrates the impact of a monetary policy shock on the economy. Following the shock, there is an increase in prices (P) and wages (w), which subsequently leads to a reduction in labor demand (L) and overall economic growth (Y). This indicates that while monetary policy can influence market conditions, the presence of monopoly power may exacerbate negative outcomes by dampening labor demand and hindering growth.

Therefore, in this study, monopoly power makes price, wage, capital rental rate, labor demand, capital demand, and economic growth more sensitive to fiscal and monetary policy shocks.

5. DISCUSSION

On working process

6. POLICY IMPLICATION

On working process

7. FUTURE RESEARCH

a more granular examination of sectoral monopolies could provide insights into how different industries respond to policy interventions. Expanding the model to include sectors like finance and energy, where monopolistic tendencies are prominent, would offer a broader understanding of monopoly power's economic implications. Moreover, further exploration of the dynamic relationship between monopolistic power and innovation, especially in technology-driven sectors, is essential.

CONCLUSIONS

Monopoly power, defined as a firm’s ability to set prices above marginal costs and maintain market dominance, presents significant concerns for market efficiency and welfare. Previous research suggests both positive and negative consequences of monopoly power, such as potential innovation incentives and long-term economic inefficiencies. This study examined the effects of monopoly power on policy performance in Thailand’s economy using a dynamic stochastic general equilibrium (DSGE) model. The analysis aimed to assess how monopoly power in the technology sector influences the impact of government policies and technological shocks on economic growth. The model was estimated using quarterly data from Thailand. The Bayesian estimation technique was applied to assess the behavior of households, firms, and government authorities in response to consumption, technology, fiscal, and monetary shocks. The findings reveal that monopoly power accelerate the effectiveness of fiscal and monetary policies. Fiscal policy shocks, such as government spending, had positive effects by increasing labor and capital demand, even in the presence of monopolistic tendencies. also, monopoly power induced the efficacy of monetary policy, as observed in the rise in prices and wages, which led to reduced labor demand and minimal impact on overall economic growth. Additionally, the effects of technology and consumption shocks on capital demand and growth were limited under monopolistic conditions, underscoring the dampening influence of market power on economic dynamics.

ACKNOWLEDGEMENT

This research is supported by the School of Economics, Sukhothai Thammathirat Open University, Thailand.

ENHANCING BUSINESS CONFIDENCE INDEX FORECASTING USING ARTIFICIAL NEURAL NETWORKS AND MULTIPLE REGRESSIONS: A CASE STUDY OF THAILAND

Adirek Vajrapatkul[A], Pinmanee Vajrapatkul[B]

ABSTRACT

This study investigates the effectiveness of Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR) in forecasting the Business Confidence Index (BCI) in Thailand, a critical indicator of business and economic health conditions. The objective is to identify key predictors that influence BCI based on the predictive capabilities of these two models which are then applied to conduct BCI forecasting. This research utilized monthly data from 2012 to 2023 obtained from the Bank of Thailand database. The predictors included in this study are Land Allocation Permits (LAP), total liabilities of commercial banks (TLC), the number of Newly Registered Juristic Persons (NRJ), the number of Unemployed Persons (UNP), Policy Interest Rates (PIR), the Price of Rice (PRC), and Government Expenditure (GEX). Results indicate the ANN model demonstrated superior predictive performance with a lower Mean Squared Error (MSE) in the testing phase (4.929), compared to MLR's MSE of 6.800. The Application of ANN revealed that LAP negatively impacts BCI (β = -3.48, p = 0.007), while PIR (β = 3.49, $p < 0.001$) and NRJ (β = 4.33, p = 0.019) positively influence it. The findings underline the importance of stable interest rate policies and support for new businesses in enhancing business confidence.

Keywords: *Business Confidence Index, Artificial Neural Network, Multiple Linear Regression, Thailand*

INTRODUCTION

Business confidence (BC), a crucial economic indicator, measures the optimism or pessimism of business owners and managers regarding the economy's current and future states. Typically assessed through surveys, it evaluates businesses' perceptions of economic conditions, their performance, and future expectations. Business confidence significantly influences economic growth. It was recognized that higher confidence levels positively impact economic growth, particularly during recessions and periods of low confidence (Guo & He, 2020). Furthermore, it predicts the future development of the economy (Suhányiová et al., 2023). The level of business confidence directly affects decision-making processes and elevated confidence often leads the countries to increased investments, hiring, and expansion plans. Conversely, lower confidence results in more cautious behavior and significantly impacts several production sectors (Suhányiová et al., 2023). Moreover, business confidence magnifies the effects of monetary and fiscal policies, particularly during economic downturns

[A] *Ph.D., School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: a.vajrapatkul@gmail.com Orcid: https://orcid.org/0000-0002-6348-8977*

[B] *Computer Engineering Department, Srinakharinwirot University, Nakhon Nayok, Thailand. Email: p.vajrapatkul@gmail.com*

(Guo & He, 2020). Therefore, governments should consider this confidence level when designing and implementing economic policies to assign the proper policies to foster business and economic development (Suhányiová et al., 2023).

There are several factors that influence business confidence, e.g., economic conditions, political evaluations, media coverage, credibility of monetary policy (Boef & Kellstedt, 2004; Mendonça & Almeida, 2018), producer prices, and interest rates (Suhányiová et al., 2023). Several researchers are employing diverse methodologies to investigate business confidence. For example, Nichifor et al. (2023) used sentiment analysis in e-commerce as a proxy for business confidence in online retail. They leverage natural language processing and machine learning to analyze customer reviews and gauge market sentiment which links to business confidence. In addition, Aguzzoli et al. (2024) combined content analysis to explore numerical indicators and subjective aspects of business confidence. Additionally, Kock (2024) utilized the PLS-SEM method to test complex models with multiple outcomes and interactions, relevant to analyzing factors influencing business confidence. These characteristics of business confidence and factors discovered are crucial for policymakers and investors who aim to tailor investment strategies.

Given that business confidence is a vital economic indicator directly influencing investment decisions, hiring, and overall economic growth, understanding its dynamics is essential. To our knowledge, research on predictors of business confidence in Thailand, particularly using machine learning techniques, is limited. Although traditional methods have been widely used to forecast this index, they may fail to capture the complex relationships and patterns inherent in the dataset. Therefore, this research contributes to this research area by trying to improve the precision and applicability of business confidence forecasting by employing machine learning techniques. To achieve these objectives, we organize the remaining of this work as follows. The second section will explore some concepts which relate to this research. The third Section will outline the research methodology employed in this study. Subsequently, the results of the analysis and discussions will be presented.

LITERATURE REVIEWS

This section explores some economic theories and empirical results to set a foundation for understanding the predictors of business confidence.

Business confidence

Business confidence refers to the optimism or pessimism business owners feel about their companies' prospects and the economy (Hardi et al., 2024). It is a crucial indicator for assessing the economy's cyclical position and forecasting output movements (Santero & Westerlund, 1996). Traditionally, business confidence has been gauged through consumer and business surveys, providing valuable insights for business and economic analysis (Santero & Westerlund, 1996). However, these surveys can be costly and time-consuming (Seki et al., 2021). Recent advancements have introduced alternative methods to measure business confidence, which include, e.g., Sentiment Indicators from Textual Data that use machine learning techniques to analyze newspaper articles (Seki et al., 2021), Machine Learning Models that employ automated variable selection to construct sentiment indicators (Claveria et al., 2020), financial variables analysis which analyze interest rate volatility to capture economic agents' expectations to reflect business confidence (Serna & Arribas, 2014). The effectiveness of these methods varies across countries and measures.

Some studies suggest that business confidence indicators are more useful than consumer confidence indicators due to a stronger relationship with output movements (Santero & Westerlund, 1996) and it is impacted by various factors, e.g., economic growth, government expenditure, interest rates, inflation, and exchange rates (Hardi et al., 2024).

Keynesian Theory: Animal Spirits

Keynesian Theory, particularly the concept of "Animal Spirits," underscores the significance of psychological factors and irrational behaviors in economic decision-making. Introduced by John Keynes in 1936, this notion emphasizes the role of emotions, intuition, and spontaneous optimism over purely rational calculations. Animal spirits represent a fusion of market psychology and rational higher-order beliefs in financial markets (Ilomäki, 2016; Ilomäki, 2018). This concept extends beyond mere uncertainty, encompassing suboptimal emotional responses to changes in socioeconomic status (Soldatos & Varelas, 2015). Recent advancements in neuroscience and psychology have enriched the comprehension of these animal spirits by illustrating how beliefs are shaped through analogical reasoning and emotional processes (Lainé, 2022).

The impact of animal spirits on economic dynamics is debated. Some research suggests that animal spirits contribute to persistent business cycles and nonlinear investment functions (Dohtani & Matsuyama, 2022), while others argue that rational investors may disregard animal spirits in financial markets (Ilomäki, 2016). Nonetheless, field studies indicate that emotions significantly influence investment decisions, especially when dealing with radical uncertainty (Lainé, 2020). The concept of animal spirits has been integrated into modern economic models, such as the IS-LM-NAC framework, which seeks to explain the influence of psychological factors on economic activity and policy outcomes (Farmer & Platonov, 2019). According to Keynes, animal spirits drive economic activity beyond rational calculations, playing a crucial role in shaping business cycles and market dynamics (Lainé, 2022).

Animal spirits form beliefs through analogical reasoning and mental shortcuts, with emotions signaling achievement levels and influencing risk-taking behavior. These spirits can incentivize belief updates but also lead to hasty conclusions, pattern recognition errors, and emotional distortions in judgment (Lainé, 2022). In investment expectations, entrepreneurs often rely on gut feelings rather than purely rational analysis (Lainé, 2020).

The theory has evolved to incorporate recent developments in neuroscience and psychology, situating animal spirits within a broader perspective of two reasoning systems operating under different degrees of uncertainty (Lainé, 2022). This updated understanding has significant implications for macroeconomic modeling and policy-making. For instance, in a New Keynesian behavioral model, animal spirits can dominate business cycle movements in rigid economies, while increased price flexibility can mitigate their impact (Grauwe & Ji, 2020). Animal spirits theory has gained renewed appreciation following the global financial crisis, which highlighted the fragility of financial markets and the capriciousness of investor sentiment (Eichengreen, 2020). Recent studies have also examined the role of animal spirits in ethical finance markets, showing that investor sentiment and consumer confidence significantly affect the dynamics of ethical stock returns (Jawadi et al., 2022).

Rational Expectations Theory

Rational Expectations Theory (RET) is a pivotal concept in macroeconomics, suggesting that individuals utilize all available information to make economic decisions and

forecast future events (Ayala & Palacio-Vera, 2014; Sargent, 2017). Initially proposed by John Muth in the 1960s and later advanced by economists such as Robert Lucas and Thomas Sargent, RET has become integral to modern macroeconomic modeling (Evans & Honkapohja, 2005; Taylor, 2001). The theory posits that individuals' expectations align with the predictions generated by the economic models that describe their behavior (Taylor, 2001). This implies that economic agents are forward-looking and their expectations are not systematically biased.

RET has been applied to explain economic issues including, e.g., inflation, financial markets, and microeconomic decision-making (Anderson, 1999; Sargent, 2017; Sheffrin, 1996). RET suggests that economic agents make accurate forecasts using all available information effectively (Yildiz & Günsoy, 2021). Even if agents initially make incorrect estimates, they adjust their expectations based on new information, avoiding systematic errors. This concept is central to 20th-century macroeconomics and finance (Wible, 2019), building on Aristotle's idea that forward-looking decisions must be based on reasoned expectations, free from the influence of passion (Curtin, 2022). However, there is no consensus among social scientists on whether rationality should be defined by the formation of expectations or by the outcomes of the formation process. The rational expectations hypothesis has faced substantial challenges and criticisms. For example, D'haultfoeuille et al. (2021) introduced a new test based on marginal distributions of realizations and subjective beliefs, which strongly rejected rational expectations about future earnings. Similarly, Johnson and Tuckett (2021) demonstrated that both amateur and expert investors often contradict rational expectations by using past public information to predict future prices, suggesting a stronger influence on narrative expectations.

Despite its widespread use, the real-world applicability of RET remains contested. Some studies present mixed evidence. For instance, research on Malaysian manufacturing businesses found that while capital expenditure forecasts were consistent with RET, revenue predictions were not (Puah et al., 2013). Additionally, some scholars argue that RET may introduce methodological bias by attributing macroeconomic instability solely to exogenous shocks, potentially overlooking inherent sources of instability (Ayala & Palacio-Vera, 2014).

While RET remains influential, recent research has led to alternative models. These include behavioral modifications such as Gabaix's boundedly rational DSGE model (Shults, 2020), diagnostic expectations (L'huillier et al., 2021), and narrative-based expectations (Johnson & Tuckett, 2021). These newer approaches aim to address the limitations of rational expectations and offer more accurate representations of how economic agents form expectations in real-world scenarios.

Prospect Theory

Prospect Theory, introduced by Daniel Kahneman and Amos Tversky in 1979, revolutionizes the understanding of decision-making under risk by challenging the traditional model of rationally expected utility maximization (Chiu & Wu, 2011). This theory has become the leading behavioral framework in the social sciences, earning its authors a Nobel Prize in economics (Barberis, 2012; Mercer, 2005). Prospect Theory elucidates the non-linear relationship between risk and reward, emphasizing how individuals perceive and evaluate potential losses and gains (Tang, 2024). A key insight of the theory is that people's attitudes toward risk vary depending on whether they are dealing with gains or losses: individuals tend to be risk-averse when considering gains and risk-seeking when facing losses (Vis, 2011).

Central to Prospect Theory are concepts like the value function and the probability weighting function, which help explain these behavioral tendencies (Chiu & Wu, 2011). Although widely adopted in behavioral economics and international relations, its reception in

political science has been mixed (Mercer, 2005; Stein & Sheffer, 2019). Some suggest this lukewarm reception may be due to political scientists' skepticism towards behavioral assumptions rather than flaws in the theory itself (Mercer, 2005). Despite these challenges, Prospect Theory has found applications across diverse domains, including tourism decision-making (Lin et al., 2023), agent-based modeling (Zhong et al., 2010), and the study of journalistic accountability (Radu, 2016). It offers a robust framework for understanding human decision-making under risk, with significant implications for complex social and political phenomena (Vis, 2011). As ongoing research continues to refine and apply the theory, its prominence in economic analysis and other fields is likely to endure (Barberis, 2012).

Recent studies have further integrated Prospect Theory with other frameworks, such as reinforcement learning theory, to develop more comprehensive models of decision-making under uncertainty (Tymula et al., 2023). A multinational study involving 4,098 participants from 19 countries replicated 94 percent of the original findings, underscoring the theory's cross-cultural validity (Ruggeri et al., 2020). This theory remains a cornerstone of behavioral economics and decision-making research. Its evolving applications, including the incorporation of time outcomes alongside monetary outcomes in decision-making models (Zhong et al., 2021), continue to provide nuanced insights into human behavior under risk and uncertainty.

In the case of the empirical area, several studies reveal that various macroeconomic, political, and policy factors shape business confidence. For instance, Boef and Kellstedt (2004) stated that presidential economic management, the ruling party, extraordinary political events, and monetary policy directly affect consumer sentiment, which can indirectly influence business confidence. Zorio-Grima and Merello (2019) and Ahmed (2020) discovered that there is a bidirectional relationship between business confidence and economic condition, i.e.,business sentiment can affect consumer confidence, which in turn impacts stock market performance and overall economic conditions. In addition, Kirchner (2020) finds that while increases in the cash rate target have a lesser effect, a rise in the 90-day bank-accepted bill rate negatively impacts business sentiment. Furthermore, Teresiene et al. (2021) demonstrate that the spread of the virus significantly impacted business sentiment, particularly in the services sector, with long-term effects varying by region. Moreover, macroeconomic factors like interest rates and inflation exert varying effects on business confidence during different economic phases, being more impactful during expansionary phases and non-financial crisis periods (Narayan et al., 2021). Additionally, external shocks produce varying regional impacts on business sentiment (Teresiene et al., 2021). Also, investor sentiment positively affects firm innovation which boosts business confidence by alleviating financing constraints and enhancing R&D investment (Lin, 2023). Production levels, production prices, and interest rates are also crucial. In the work of Suhányiová et al. (2023), they report positive relationships between the Business Confidence Indicator (BCI) and production and long-term interest rates, while negative relationships exist between BCI and the Producer Prices Index (PPI) and short-term interest rates. Furthermore, environmental, social, and governance (ESG) factors contribute to business confidence. Adopting ESG policies can enhance innovation capacity, value creation, and financial performance, thereby potentially boosting business confidence (Ahmad et al., 2023). The work of Durrani et al. (2023) confirms that political factors critically affect business confidence, with elections and terror attacks having significant impacts, particularly in developing nations. Generally, economic growth, inflation, and stock market performance boost business confidence, whereas higher interest rates and exchange rates tend to diminish it (Hardi et al., 2024).

METHODOLOGY

Artificial neuron models are computational units designed to mimic the basic functioning of biological neurons, serving as the fundamental building blocks of artificial neural networks. These models have been applied across various domains and have evolved to address different challenges in machine learning and artificial intelligence. For example, in chemistry, an artificial neural network model was developed to predict the surface tension of liquid organic fatty acids over a wide temperature range (Pierantozzi et al., 2021). This model utilized a 41-neuron hidden layer and achieved high accuracy in predicting surface tension, outperforming traditional corresponding-states correlations. In economics, it has been applied to stock market prediction, credit risk assessment, and economic forecasting (Cansu et al., 2024). The artificial neuron model (Khashei & Bijari, 2010) can be formulated as follows:

Each neuron in the hidden layer and output layer uses a weighted sum of the inputs, and applies an activation function to produce an output. For neuron *j* in the hidden layer:

$$z_j = \sum_{i=1}^{7} w_{ij} x_i - \theta_j, \tag{1}$$

where x_i represents the independent variables. w_{ij} represents the weight between the input and the neuron j. θ_j is the bias or threshold for neuron j. z_j is the weighted sum input to neuron j.

In this study, Sigmoid activation function $f(z_j) = \frac{1}{1+e^{-z_j}}$ is applied to the weighted sum z_j to produce the output of neuron j. The final predicted BCI can be modeled using the weighted sum of the hidden layer outputs as follows:

$$y = f\left(\sum_{j=1}^{n_h} w_j^{(h)} y_j - \theta_o \right), \tag{2}$$

where n_h is the number of neurons in the hidden layer. $w_j^{(h)}$ are the weights connecting the hidden layer neurons to the output neuron. y_j is the output from the j hidden layer neuron. θ_o is the bias or threshold for the output neuron. The representation of ANN is exhibit by Figure 1.

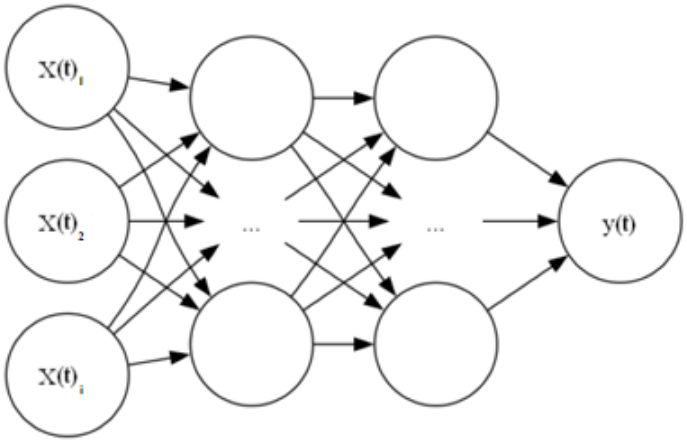


Figure 1 – ANN model

This study examines predictors, including the Business Confidence Index (BCI), Land Allocation Permits (LAP), and total liabilities of commercial banks (TLC). Additionally, it considers the number of Newly Registered Juristic Persons (NRJ), the count of Unemployed Persons (UNP), Policy Interest Rates (PIR), the Price of Rice (PRC), and Government Expenditure (GEX).

The analysis utilizes monthly data from January 2012 to July 2023 from the Bank of Thailand. The data was analyzed using Python, with custom coding developed by the author.

RESULT

This section details the results of Multiple Linear Regression (MLR) and Artificial Neural Networks (ANN). Additionally, it covers statistical evaluations of key predictors, comparisons of model performance, and a forecast of business confidence.

The dynamics of variables in this study are represented in Figure 2.

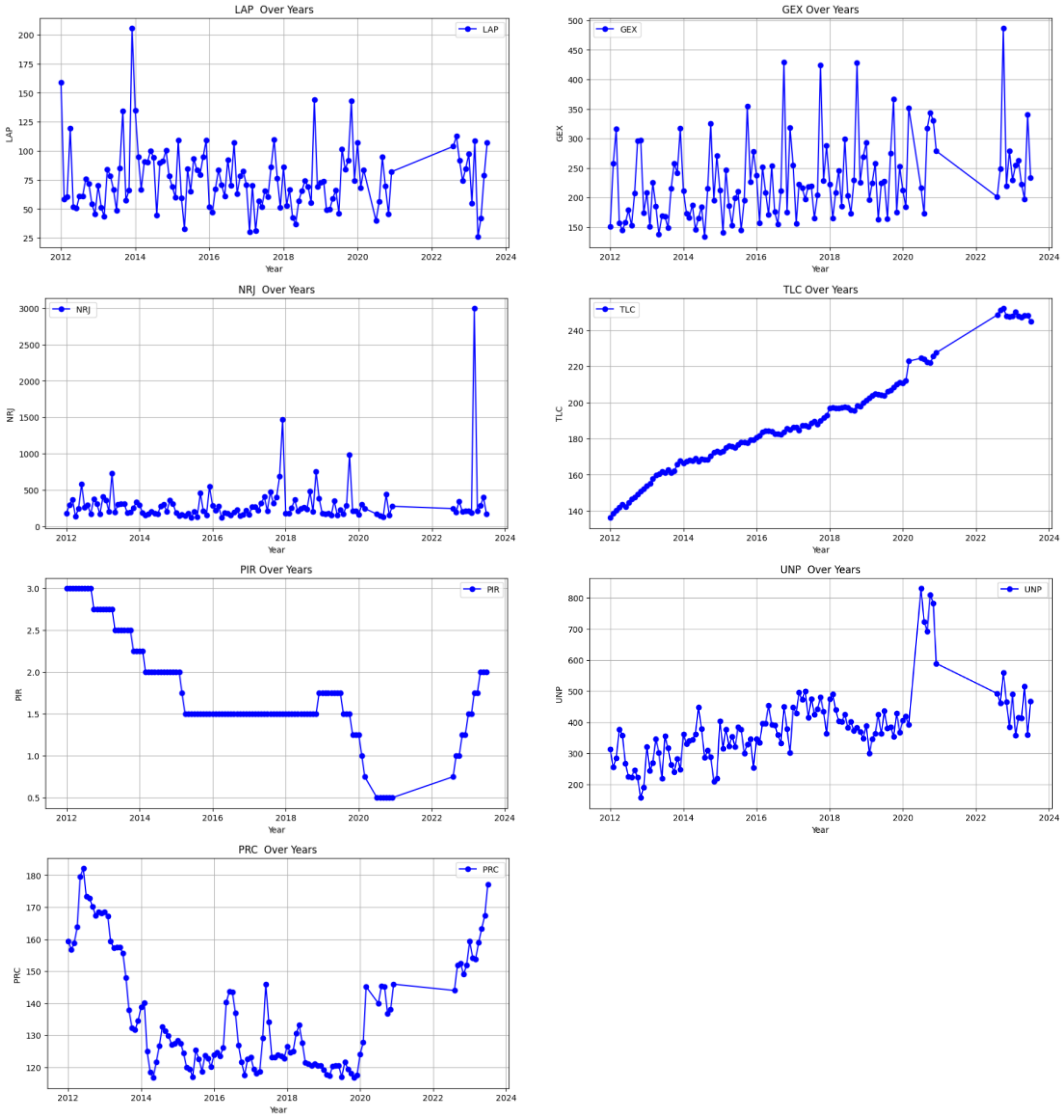


Figure 2 – Data series of variables

Table 1 – Full multiple regression model estimation

	coef	std err	t	P>|t|	0.025	0.975
const	46.8493	1.752	26.735	0	43.376	50.322
LAP	-3.6194	1.289	-2.809	0.006	-6.173	-1.065
TLC	1.4796	1.382	1.071	0.287	-1.259	4.218
NRJ	3.753	1.913	1.962	0.052	-0.038	7.544
UNP	0.2766	1.887	0.147	0.884	-3.463	4.017
PIR	5.3729	2.049	2.623	0.01	1.312	9.433
PRC	-0.8108	1.053	-0.77	0.443	-2.899	1.277
GEX	0.6189	1.095	0.565	0.573	-1.551	2.788

Table 1 reveals that LAP and PIR significantly influence the Business Confidence Index (BCI). Specifically, LAP has a negative effect on BCI ($\beta = -3.62$, $p = 0.006$), while PIR shows a positive association ($\beta = 5.37$, $p = 0.010$). NRJ has a marginally significant positive impact ($\beta = 3.75$, $p = 0.052$). However, TLC, UNP, PRC, and GEX are not statistically significant, indicating no meaningful influence on BCI.

Table 2 – Reduce Multiple regression model estimation

	coef	std err	t	P>|t|	[0.025	0.975]
const	48.4163	0.562	86.148	0.000	47.303	49.53
LAP	-3.4816	1.259	-2.766	0.007	-5.975	-0.988
NRJ	4.3343	1.822	2.378	0.019	0.724	7.945
PIR	3.4873	0.789	4.419	0.000	1.924	5.051

Table 2 shows that LAP, NRJ, and PIR significantly influence the Business Confidence Index (BCI). LAP maintains a negative relationship with BCI ($\beta = -3.48$, $p = 0.007$), while both NRJ ($\beta = 4.33$, $p = 0.019$) and PIR ($\beta = 3.49$, $p < 0.001$) exhibit positive effects.

Table 3 – correlation analysis

	LAP	NRJ	PIR	BCI
LAP	1	0.09957	0.024264	-0.20243
NRJ	0.09957	1	0.03043	0.186935
PIR	0.024264	0.03043	1	0.368026
BCI	-0.20243	0.186935	0.368026	1

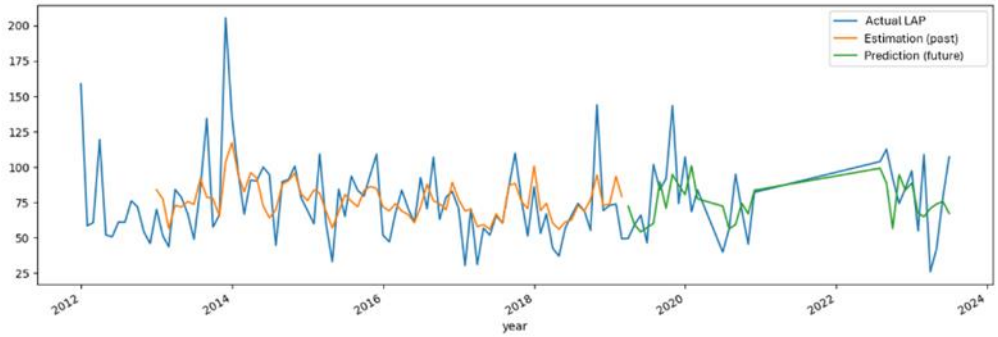
The correlation analysis in Table 3 shows the relationships between BCI, LAP, NRJ, and PIR. LAP has a negative correlation with BCI (-0.202), indicating that as LAP increases, BCI tends to decrease. In contrast, both NRJ (0.187) and PIR (0.368) have positive correlations with BCI, suggesting that higher values of NRJ and PIR are associated with increases in BCI.

The predicted values of the selected variables using the ANN model are shown in equations (3) – (5) and Figure 2. The results are illustrated in Figures 3, 4, and 5.

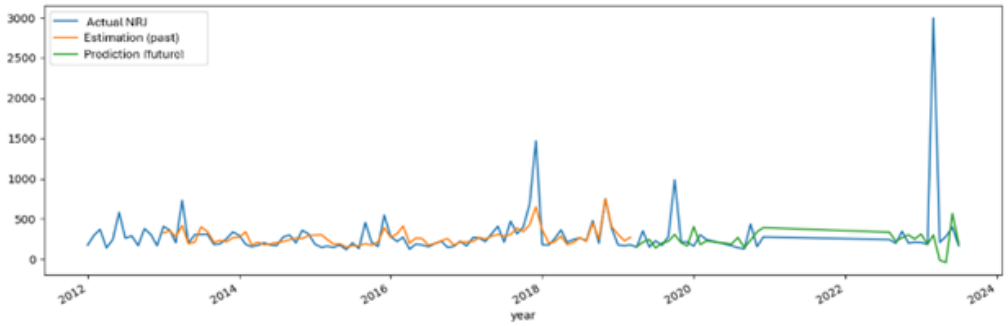
$$\mathrm{LAP}_t = \mathrm{f}(\mathrm{LAP}_{t-1}, \mathrm{LAP}_{t-2}, \mathrm{LAP}_{t-3}, \dots, \mathrm{LAP}_{t-12}), \quad (3)$$

$$\mathrm{NRJ}_t = \mathrm{f}(\mathrm{NRJ}_{t-1}, \mathrm{NRJ}_{t-2}, \mathrm{NRJ}_{t-3}, \dots, \mathrm{NRJ}_{t-12}), \quad (4)$$

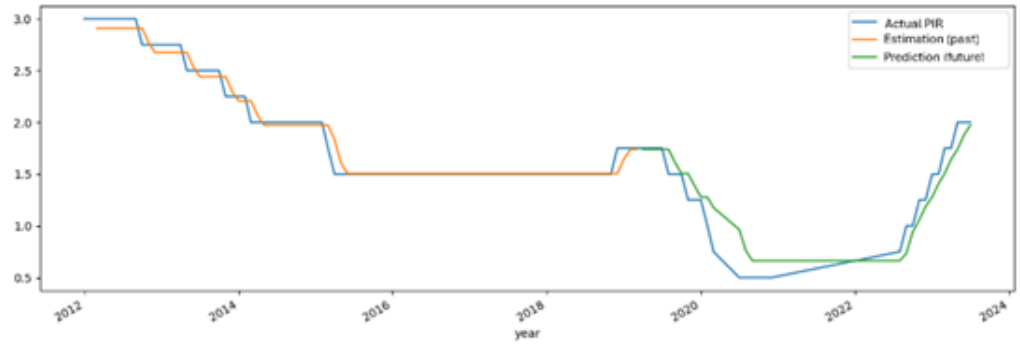
$$\mathrm{PIR}_t = \mathrm{f}(\mathrm{PIR}_{t-1}, \mathrm{PIR}_{t-2}). \quad (5)$$



(a)

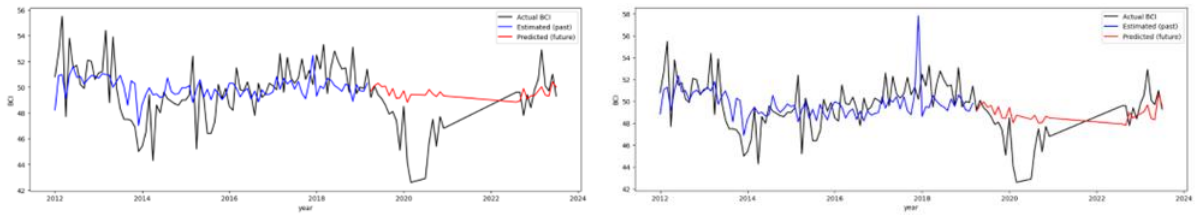


(b)



(c)

Figure 3 – Actual, estimated, and predicted values of (a) LAP, (b) NRJ, and (c) PIR



(a) (b)

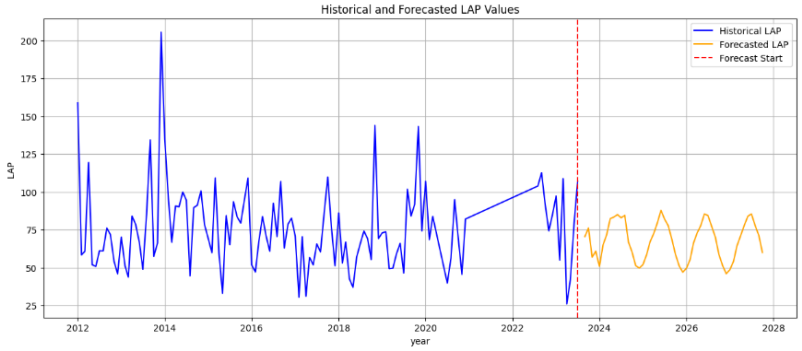
Figure 4 – BCI Prediction from (a)M LR and (b) ANN

Figure 4 presents the predicted BCI by MLR and ANN, respectively.

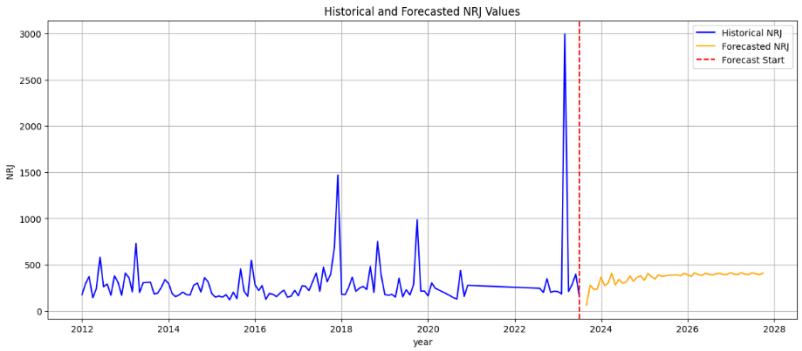
Table 4 – Mean Squared Error comparison

	MLR	ANN
Mean Squared Error train	3.927	4.497
Mean Squared Error test	6.800	4.929

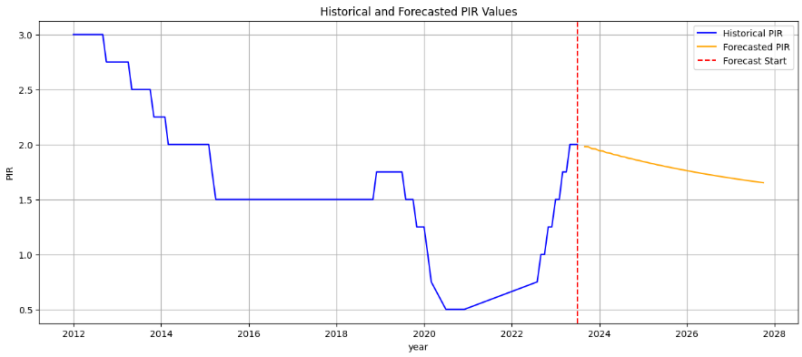
The Mean Squared Error (MSE) comparison in Table 4 evaluates the predictive performance of the Multiple Linear Regression (MLR) model and the Artificial Neural Network (ANN) model. The MLR model shows a lower training MSE of 3.927 but a higher testing MSE of 6.800, indicating that it performs well during training but less effectively when tested on new data. In contrast, the ANN model has a higher training MSE of 4.497 but a notably lower testing MSE of 4.929. It suggests that while the ANN model may be less accurate during training, it generalizes better to new data than the MLR model. This indicates that the ANN model is more reliable for forecasting the Business Confidence Index (BCI) based on its testing phase performance.



(a)



(b)



(c)

Figure 5 – Actual and forecast of (a) LAP, (b) NRJ, and (c) PIR

Figure 5 exhibits the forecasted values of LAP, NRJ, and PIR.

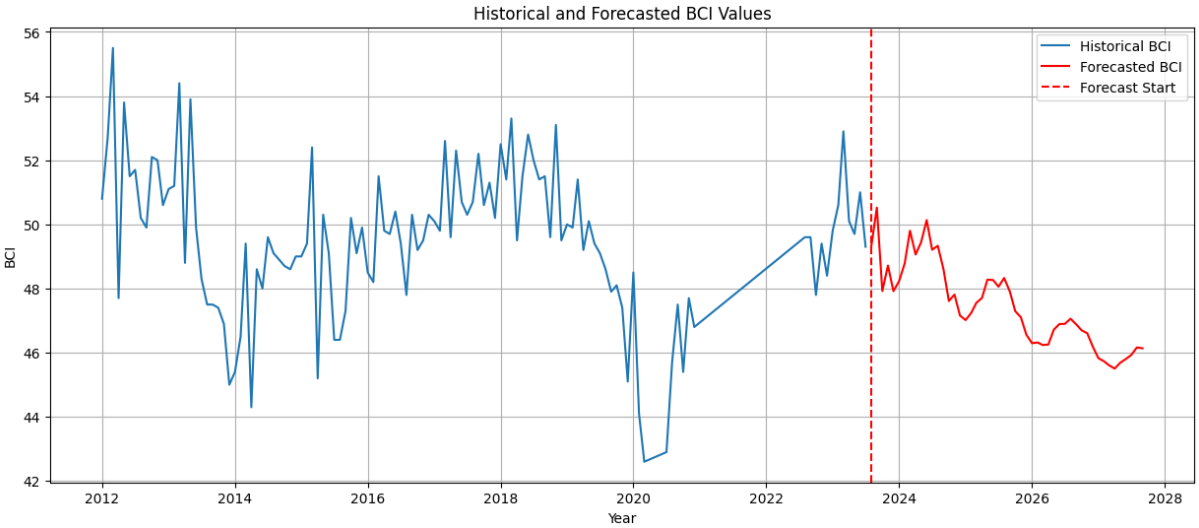


Figure 6 – Actual and forecast of BCI

Figure 6 displays the trend of the Business Confidence Index (BCI) over time, including both historical data and future forecasts. The forecasted trend starts in August 2023 and continues until August 2027. The red line representing the forecasted BCI values shows a general downward trend after the forecast starts. This suggests that business confidence will decrease over the forecast period, with minor fluctuations observed.

DISCUSSION

The results from the multiple regression analysis indicate that LAP, NRJ, and PIR are significant factors influencing the Business Confidence in Thailand. Specifically, LAP negatively affects BCI, indicating that increased land allocation activities correlate with decreased business confidence. This could suggest that rising land allocations might be associated with economic conditions that deter business optimism, such as speculative investments or market uncertainties. On the other hand, PIR shows a positive relationship with BCI, implying that higher policy interest rates boost business confidence, potentially reflecting a stable economic environment that encourages investment. NRJ also has a marginally significant positive effect on BCI, suggesting that the growth in new businesses correlates with increased business optimism.

The findings align with and are supported by several theoretical perspectives. Keynesian Theory's concept of "Animal Spirits," which emphasizes the psychological factors and irrational behaviors in economic decision-making, can partially explain the observed effects of LAP and PIR on BCI. According to Keynesian theory, investor sentiment and business confidence are often influenced by emotions and perceptions of economic stability rather than purely rational calculations (Lainé, 2022). The positive impact of PIR on BCI, as found in this study, supports the idea that businesses interpret rising interest rates as signals of a healthy economy, leading to enhanced confidence. This observation mirrors the findings of Suhányiová et al. (2023), who reported a positive correlation between long-term interest rates and BCI.

The results also resonate with aspects of Rational Expectations Theory (RET). RET posits that individuals use all available information to make forecasts and align their expectations accordingly (Sargent, 2017). The significant positive effect of NRJ on BCI found in this study suggests that businesses are forward-looking and anticipate growth opportunities based on the increasing number of new market entrants. This aligns with RET's assumption that economic agents adjust their behavior based on new data to avoid systematic errors, reflecting rational decision-making. This empirical finding also parallels the Prospect Theory, which suggests that individuals are risk-averse when considering gains but risk-seeking in the face of potential losses (Kahneman & Tversky, 1979). The negative relationship between LAP and BCI could be interpreted through the lens of Prospect Theory, where businesses may exhibit cautious behavior in response to increased land allocation, perceiving it as a potential risk to their future gains. This cautious outlook could be tied to uncertainties in property markets or broader economic conditions that make businesses hesitant to invest or expand.

The broader literature on business confidence and economic indicators supports the study's conclusion that macroeconomic factors like interest rates and newly registered businesses play a crucial role in shaping business sentiment. Previous studies consistently show that stable macroeconomic environments, characterized by moderate interest rates and increasing entrepreneurial activity, foster business optimism (Hardi et al., 2024; Narayan et al., 2021). Similarly, this study's findings reinforce the observations by Suhányiová et al. (2023) that production levels and interest rates directly impact business confidence. However, the study also presents deviations from some theoretical predictions, particularly concerning LAP's negative influence on BCI. Traditional economic theories might expect land allocation to signal growth and investment potential. However, the negative correlation found in this research suggests that other contextual factors, possibly related to speculative pressures or regulatory uncertainties, might be at play.

POLICY IMPLICATION

The results of our analysis suggest several critical policy implications. According to the positive impact of Policy Interest Rates (PIR) on business confidence, it indicates that maintaining a balanced interest rate policy is crucial. Policymakers should consider carefully calibrated interest-rate adjustments that signal economic stability, as higher rates seem to boost business confidence in this context. Regarding the significant influence of Newly Registered Juristic Persons (NRJ) on BCI, it highlights the importance of supporting new business ventures. Policies that streamline business registration processes, reduce bureaucratic hurdles, and provide incentives for startups could further stimulate entrepreneurial activity, thereby enhancing business confidence. Conversely, the negative relationship between Land Allocation Permits (LAP) and BCI suggests that increased land allocation might be perceived as a sign of market uncertainty or speculative risk. To mitigate this, policies should improve transparency in land allocation practices and regulate speculative activities to stabilize investor sentiment.

FUTURE RESEARCH

Future research should include new potential predictors in the model to refine the results. Also, the research should expand the use of advanced machine learning techniques, such as deep learning models, to improve the accuracy of the analysis.

CONCLUSION

Business confidence is a critical indicator reflecting business sentiment which can influence investment decisions and economic growth. This research aimed to identify the predictors and forecast for Thailand's Business Confidence. This study employs Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR) models to analyze the monthly data from January 2012 to July 2023, obtained from the Bank of Thailand. This dataset included the Business Confidence Index (BCI), Land Allocation Permits (LAP), total liabilities of commercial banks (TLC), the number of Newly Registered Juristic Persons (NRJ), the number of Unemployed Persons (UNP), Policy Interest Rates (PIR), the Price of Rice (PRC), and Government Expenditure (GEX). This study first tries to evaluate the predictive capabilities of these models by comparing their performances which revealed that the ANN outperformed MLR. Then we used the selected model to identify the predictors of BCI. The results indicated that LAP negatively impacts BCI. Conversely, PIR and NRJ positively influence BCI. These findings suggest that an appropriate interest rate policy is crucial to sustaining business confidence. Furthermore, encouraging new business registrations through streamlined processes and reduced barriers can significantly boost business sentiment.

ACKNOWLEDGMENT

This research is supported by the School of Economics, Sukhothai Thammathirat Open University, Thailand. This research is also supported by the computer engineering department Srinakharinwirot University, Nakhon Nayok, Thailand.

REFERENCES

Ahmad, H., Yaqub, M., & Lee, S. H. (2023). Environmental, social, and governance-related factors for business investment and sustainability: A scientometric review of global trends. *Environment, Development and Sustainability, 26*(2), 2965–2987. https://doi.org/10.1007/s10668-023-02921-x

Anderson, H. M. (1999). Explanations of an empirical puzzle: What can be learnt from a test of the rational expectations hypothesis? *Journal of Economic Methodology, 6*(1), 31–59. https://doi.org/10.1080/13501789900000002

Ayala, I. H., & Palacio-Vera, A. (2014). The Rational Expectations Hypothesis: An assessment from Popper's philosophy. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.2382841

Barberis, N. C. (2012). Thirty years of prospect theory in economics: A review and assessment. *Journal of Economic Perspectives, 27*(1), 173–196. https://doi.org/10.1257/jep.27.1.173

Bielova, I., Halík, J., & Ryabushka, L. (2021). The causal nexus of consumer and business confidence indexes in early pandemic period: Evidence from OECD countries. *Journal of Risk and Financial Management, 14*(7), 311. https://doi.org/10.3390/jrfm14070311

Chiu, A., & Wu, G. (2011). Prospect theory. *Wiley Encyclopedia of Operations Research and Management Science.* https://doi.org/10.1002/9780470400531.eorms0687

Claveria, O., Monte, E., & Torra, S. (2020). Economic forecasting with evolved confidence indicators. *Economic Modelling*, *93*, 576–585. https://doi.org/10.1016/j.econmod.2020.09.015

Curtin, R. T. (2022). A new theory of expectations. *Journal of Business Cycle Research, 18*(3), 239–259. https://doi.org/10.1007/s41549-022-00074-w

De Boef, S., & Kellstedt, P. M. (2004). The political (and economic) origins of consumer confidence. *American Journal of Political Science, 48*(4), 633–649. https://doi.org/10.1111/j.0092-5853.2004.00092.x

De Grauwe, P., & Ji, Y. (2020). Structural reforms, animal spirits, and monetary policies. *European Economic Review, 124,* 103395. https://doi.org/10.1016/j.euroecorev.2020.103395

Dohtani, A., & Matsuyama, J. (2022). A business-cycle model connecting heterogeneous micro investment behaviors with macro dynamics. *Communications in Nonlinear Science and Numerical Simulation, 117,* 106903. https://doi.org/10.1016/j.cnsns.2022.106903

Durrani, N., Ahmed, J., & Fatima, K. (2023). The role of economic and political factors in shaping consumers' confidence in Pakistan. *Journal of Social Sciences Review, 3*(2), 718–735. https://doi.org/10.54183/jssr.v3i2.237

Eichengreen, B. (2020). Keynesian economics: Can it return if it never died? *Review of Keynesian Economics, 8*(1), 23–35. https://doi.org/10.4337/roke.2020.01.03

Evans, G. W., & Honkapohja, S. (2005). An interview with Thomas J. Sargent. *Macroeconomic Dynamics, 9*(4), 561–583. https://doi.org/10.1017/s1365100505050042

Farmer, R. E. A., & Platonov, K. (2019). Animal spirits in a monetary model. *European Economic Review, 115,* 60–77. https://doi.org/10.1016/j.euroecorev.2019.02.005

Guo, Y., & He, S. (2020). Does confidence matter for economic growth? An analysis from the perspective of policy effectiveness. *International Review of Economics & Finance, 69,* 1–19. https://doi.org/10.1016/j.iref.2020.04.012

Hardi, I., Duwal, N., Mardayanti, U., Ali, N., Idroes, G. M., & Devi, N. C. (2024). Business confidence in Indonesia: Which macroeconomic factors have long-term impact? *Indatu Journal of Management and Accounting, 2*(1), 40–54. https://doi.org/10.60084/ijma.v2i1.203

Ilomäki, J. (2016). Animal spirits, beauty contests, and expected returns. *Journal of Economics and Finance, 41*(3), 474–486. https://doi.org/10.1007/s12197-016-9364-8

Jawadi, F., Jawadi, N., & Cheffou, A. I. (2022). Testing the animal spirits theory for ethical investments: Further evidence from aggregated and disaggregated data. *Annals of Operations Research, 45*(24), 461–479. https://doi.org/10.1007/s10479-022-04832-y

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263–291.

Khashei, M., & Bijari, M. (2010). An artificial neural network (pdq) model for timeseries forecasting. *Expert Systems with Applications, 37*(1), 479–489. https://doi.org/10.1016/j.eswa.2009.05.044

Kirchner, S. (2020). The effect of changes in monetary policy on consumer and business confidence. *Australian Economic Review, 53*(1), 118–125. https://doi.org/10.1111/1467-8462.12365

Lainé, M. (2022). Towards a general modern theory of animal spirits. *Review of Keynesian Economics, 10*(1), 63–87. https://doi.org/10.4337/roke.2022.01.04

Lin, G., Song, H., & Lin, M. S. (2023). An assessment of prospect theory in tourism decision-making research. *Journal of Travel Research, 63*(2), 275–297. https://doi.org/10.1177/00472875231171673

Mendonça, H. F., & Almeida, A. F. G. (2018). Importance of credibility for business confidence: Evidence from an emerging economy. *Empirical Economics, 57*(6), 1979–1996. https://doi.org/10.1007/s00181-018-1533-5

Narayan, S., Bui, M. N. T., Ren, Y., & Ma, C. (2021). Macroeconomic determinants of US corporate leverage. *Economic Modelling, 104,* 105646. https://doi.org/10.1016/j.econmod.2021.105646

Nichifor, E., Albu, R.-G., Chișinău, E. M., Brătucu, G., Lupșa-Tătaru, D. A., Bălășescu, S., Chițu, I. B., & Todor, R. D. (2023). Utilising artificial intelligence to turn reviews into business enhancements through sentiment analysis. *Electronics, 12*(21), 4538. https://doi.org/10.3390/electronics12214538

Puah, C.-H., Wong, S. S.-L., & Liew, V. K.-S. (2013). Testing rational expectations hypothesis in the manufacturing sector in Malaysia. *Journal of Business Economics and Management, 14*(2), 303–316. https://doi.org/10.3846/16111699.2011.631743

Santero, T., & Westerlund, N. (1996). Confidence indicators and their relationship to changes in economic activity. *Organisation for Economic Co-operation and Development.* https://doi.org/10.1787/537052766455

Seki, K., Ikuta, Y., & Matsubayashi, Y. (2021). News-based business sentiment and its properties as an economic index. *Information Processing & Management, 59*(2), 102795. https://doi.org/10.1016/j.ipm.2021.102795

Suhányiová, A., Suhányi, L., & Kočišová, M. (2023). Business confidence in the sustainable manufacturing sector in the context of production, production prices, and interest rates. *Sustainability, 16*(1), 173. https://doi.org/10.3390/su16010173

Taylor, J. (2001). How the rational expectations revolution has changed macroeconomic policy research. In *Economics and Finance: The Rational Expectations Revolution* (pp. 79–96). Palgrave Macmillan. https://doi.org/10.1057/9780333992753_5

Vis, B. (2011). Prospect theory and political decision-making. *Political Studies Review, 9*(3), 334–343. https://doi.org/10.1111/j.1478-9302.2011.00238.x

Zorio-Grima, A., & Merello, P. (2019). Consumer confidence: Causality links with subjective and objective information sources. *Technological Forecasting and Social Change, 150,* 119760. https://doi.org/10.1016/j.techfore.2019.119760

RETAIL SALES FORECASTING USING MACHINE LEARNING TECHNIQUES: A COMPARATIVE ANALYSIS OF MLR, ANN, AND KNN MODELS

Adirek Vajrapatkul[A], Pinmanee Vajrapatkul[B]

ABSTRACT

Retail sales forecasting plays a pivotal role in business and economic planning, directly influencing strategies in inventory management, marketing, financial operations, and economic growth. This research aims to forecast retail sales utilizing three models, namely Multiple Linear Regression (MLR), Artificial Neural Networks (ANN), and K-Nearest Neighbors (KNN). This study utilized monthly data from January 2009 to April 2024, obtained from the Bank of Thailand, key features include Policy Interest Rate (PIR), Wholesale Price of Consumer Goods (WPC), Commercial Bank Credit (CBC), Currency in Circulation (CIC), Government Expenditure (GEX), and Import Price Index (IPI) which were analyzed to forecast the Retail Sales Index (REI). The models were evaluated based on Mean Absolute Percentage Error (MAPE) which revealed that KNN achieved the highest accuracy. The results show that PIR, GEX, and CIC positively influence retail sales, while WPC has a negative effect. These findings highlight the importance of maintaining favorable interest rates, currency liquidity, and price control strategies to sustain retail sales growth.

Keywords: *Retail Sales, Machine Learning, Multiple Linear Regression, Artificial Neural Networks, K-Nearest Neighbors, Thailand*

INTRODUCTION

Retail sales refer to the direct sale of goods or services to consumers for personal use through various channels, such as physical stores, online platforms, or direct marketing. This process is a fundamental component of the retail sector, which significantly impacts the global economy. Retail sales contribute substantially to national GDP and economic stability (Ramadan & Morshed, 2024) and serve as a crucial link between industries such as manufacturing and logistics, creating a ripple effect throughout the economy. This retail sector's performance is often an indicator of overall economic health (Wang & Jones, 2001), employment, and economic growth (Ramadan & Morshed, 2024), particularly in developing economies (Wang & Song, 2008).

Retail sales offer insights into several aspects of business and economic domains, e.g., it allows to understand consumer preferences and purchasing patterns, which are vital for businesses to adapt their strategies. Moreover, the retail sector shapes urban landscapes and influences spatial development patterns. This is evident in the spatial restructuring and retail

[A] *Ph.D., School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: a.vajrapatkul@gmail.com Orcid: https://orcid.org/0000-0002-6348-8977*

[B] *Computer Engineering Department, Srinakharinwirot University, Nakhon Nayok, Thailand. Email: p.vajrapatkul@gmail.com*

suburbanization observed in Chinese cities (Wang & Song, 2008) and in the areas with high market potential (Klaesson & Öner, 2014). The total retail sales of consumer goods also serve as an essential indicator of consumption levels and overall economic health, especially in rapidly developing economies like China (Liu et al., 2021). Furthermore, retail sales stimulate consumer demand, create employment opportunities, and drive economic growth (Wang et al., 2022). In emerging countries, traditional retail formats like wet markets account for a significant proportion of retail sales, contributing to economic value (Tran, 2023). In addition, retail sales act as a vital link between industries such as manufacturing and logistics (Ramadan & Morshed, 2024) which support the growth of business activities.

Identifying retail sales determinants helps businesses optimize strategies and improve performance which is crucial for businesses, and policymakers. Researchers have continuously examined the determinants of retail sales through various methodologies. Numerous studies have employed quantitative methods to analyze these features. For example, in Norway, a natural experiment demonstrated that proximity to liquor stores and extended opening hours significantly impacted food retail sales and customer numbers (Gripsrud & Horverak, 1986). Some studies have focused on unique aspects of retail sales determinants. For instance, one study established a statistically significant connection between skylighting and retail sales performance by comparing average sales for 108 stores of a retail chain while controlling for various features (Heschong et al., 2002). In China, researchers adopted a grid-division strategy to investigate micro-level determinants of retail sales, finding that nearby population, road length, and non-commercial points of interest positively influenced sales, while commercial facilities and geographic barriers had negative effects (Wang et al., 2022). In the investigation process, it was discovered that various features that impact retail sales, e.g., retail atmospherics (Noad & Rogers, 2008), selling techniques (Rippé et al., 2016), population density, average store size, foreign trade ratio, economic freedom, urban population percentage (Roche et al., 2019), location-based socioeconomic characteristics, spatial competition, store attributes significantly impact retail sales (Maican & Orth, 2021; Wang et al., 2022), high-productivity stores (Maican & Orth, 2021), consumer benefits and loyalty, perceived value, practical benefits, user-friendliness (Wohllebe et al., 2020), special treatment (Channa et al., 2020), and modern retail practices by artificial intelligence (AI) (Malhotra & Ramalingam, 2023).

Despite the wealth of research focusing on micro-level features affecting retail sales, such as consumer behaviour and store-specific attributes, there is a noticeable gap in understanding how macro-level features impact retail performance. This research addresses this gap by investigating how key macro-level features affect retail sales in Thailand, especially by applying machine learning techniques. To achieve these objectives, we organize the remaining of this work as follows. The second section will explore the concepts related to this research. Section 3 will outline the research methodology employed in this study. Subsequently, the results of the analysis and discussions will be presented.

LITERATURE REVIEWS

In this section, we review relevant theories and concepts to provide a theoretical and empirical foundation for this study. The literature review examines key frameworks, i.e., demand theory, fiscal policy, and monetary policy, as well as previous studies on retail sales forecasting. This section aims to highlight the need for further exploration into the impact of macro-level features on retail sales.

Demand Theory

Demand theory, a pivotal economic framework, elucidates consumer behavior and purchasing decisions through the interplay of price, quantity, and utility. It provides insights into how consumers allocate their limited resources among various goods and services to maximize satisfaction (Rachlin et al., 1976). The theory presumes rational consumer choices aimed at maximizing utility within budget constraints. Key analytical tools include budget lines, indifference curves, and substitutability, which facilitate the examination of consumer choices across different commodities (Rachlin et al., 1976). This theory explains the impact of price changes on consumption patterns, i.e., consumers typically favor lower-priced commodities while reducing consumption of higher-priced ones (Rachlin et al., 1976). Demand theory remains a foundational concept in economics, elucidating how consumers make purchasing decisions based on price and utility. It posits that consumer behavior is influenced by the relationship between a product's price and the quantity demanded. In the context of consumer buying decisions, demand theory suggests that consumers aim to maximize utility within budget constraints.

Several studies tried to discover the causes of the variation in quantity of demand, e.g. Dangi et al. (2021) explore how quality, trust, and social features shape customer perception and purchase intentions for branded products. Pahari et al. (2023) discuss how perception and health consciousness influence attitudes towards organic food. Additional research highlights the role of external features and unexpected events in shaping consumer behavior. Xu et al. (2023) discuss how panic buying, triggered by extreme weather and epidemics, impacts retailers' inventory management. Aljanabi (2021) examines the effects of economic policy uncertainty and information overload on panic buying during the COVID-19 pandemic. Xu et al. (2023) illustrate how unexpected events can trigger panic buying, affecting inventory management and altering the typical demand curve. Xu et al. (2023) also examine how preferences for freshness and low carbon footprints impact decision-making in dual-channel supply chains. Pahari et al. (2023) highlight how health consciousness and perceptions shape attitudes and buying intentions for organic food. Liu et al. (2023) discuss "revenge spending" post-COVID-19, demonstrating how emotional features influence behavior and purchasing decisions. Baltaci et al. (2024) show how green marketing and brand awareness influence purchase intentions, mediated by the theory of planned behavior. Alam et al. (2024) extend this theory by incorporating environmental knowledge and perceived value to predict eco-labeled product buying behavior. While these studies do not directly address demand theory, they reveal various features influencing buying decisions, including psychological, social, and economic aspects. This underscores the necessity of considering a broader range of influences beyond traditional economic models to understand consumer behavior comprehensively.

While demand theory provides a foundation for understanding consumer decisions based on price and utility, modern research indicates a complex interplay of features. It often assumes positive quantities for all commodities, which is not always realistic. The concept of "hierarchic demand systems" addresses this by considering that only a subset of commodities may be purchased (Jackson, 1984). Additionally, demand theory tends to neglect non-economic features that influence preferences, consumer attitudes, and values. It fails to adequately account for the dynamic processes of choice, purchasing, and consumption, often treating these as synonymous (Mason, 1983). Also, features such as non-rational decision-making, the influence of service personnel, and the impact of social media on consumer behavior are not thoroughly addressed in traditional demand theory (Azad et al., 2023; Crozier & Mclean, 1997). Therefore, a more comprehensive approach that integrates psychological,

social, and contextual elements is essential to fully grasp and predict consumer purchasing decisions.

Fiscal policy

Fiscal policy strategically employs government spending and taxation to influence economic conditions, crucially managing aggregate demand. Government spending directly increases aggregate demand, while taxation adjustments affect consumer spending and business investment. The Fiscal Effect (FE) measure, introduced by Cashin et al. (2018), quantifies fiscal policy's impact on aggregate demand by breaking it down into discretionary, cyclical, and residual components, thereby offering a detailed analysis of fiscal policy's effects on economic growth. Fiscal policy is categorized into two main types: expansionary and contractionary. Expansionary fiscal policy, characterized by increased government spending or reduced taxes, stimulates aggregate demand and economic activity. For instance, a post-Kaleckian model for EU15 countries demonstrates that increased government spending boosts economic activity across all member states, highlighting the benefits of expansionary fiscal policy (Obst et al., 2020). Likewise, a two-country core-periphery New Keynesian model in a currency union indicates that optimal union-wide fiscal policy should be expansionary when facing the zero lower bound on interest rates (Cook & Devereux, 2019).

Fiscal policy is a crucial instrument for managing aggregate demand, working in tandem with monetary policy to stabilize the economy and promote growth (Bilbiie et al., 2024; Khalid et al., 2024). Government expenditure directly boosts aggregate demand by injecting funds into the economy, while tax policies shape consumer spending and business investment. For instance, tax reductions can enhance disposable income, leading to increased consumption (Khalid et al., 2024). Fiscal policy exerts both immediate and long-term effects on the economy, affecting output cyclicality and volatility in the short run, and influencing both demand and supply sides over the long term (Khalid et al., 2024). Expansionary fiscal policy, such as heightened government spending or tax cuts, stimulates aggregate demand by promoting consumption, investment, and government expenditure (Bilbiie et al., 2024; Parui, 2023). Conversely, contractionary fiscal policy reduces aggregate demand. The efficacy of fiscal policy in managing aggregate demand varies among economic sectors. For example, research on the Norwegian economy demonstrates that expansionary fiscal policy significantly influences industry structure, enhancing value-added in the non-traded goods sector while diminishing it in the traded goods sector (Boug et al., 2023)

The effectiveness of fiscal policy is contingent on economic conditions and policy design. For example, in a liquidity trap, fiscal policy can be particularly potent, though its international spillover effects may differ from domestic impacts (Cook & Devereux, 2011). The composition of fiscal measures is crucial; government spending and public investment often stimulate the economy more effectively than tax reductions (Junior et al., 2017). Fiscal policy's role in managing aggregate demand relies on both automatic stabilizers and discretionary measures. Automatic stabilizers frequently have a stronger impact on stabilizing output than discretionary fiscal policy, with government size being a key determinant of fiscal policy stance across countries (Fatás & Mihov, 2012). Moreover, population aging may weaken the output effects of fiscal spending shocks during recessions, necessitating larger fiscal stimuli to support aggregate demand in aging societies (Honda & Miyamoto, 2021). The impact of public spending on economic growth also depends on features such as institutional quality, expenditure composition, and fiscal architecture (Chugunov et al., 2021). While fiscal policy is a powerful tool for managing aggregate demand, its effectiveness is not uniform. The interplay between fiscal and monetary policies, as well as considerations of stabilization and

redistribution, further complicate the relationship between fiscal policy and aggregate demand (Bilbiie et al., 2024). Policymakers must carefully consider these features when designing fiscal measures to influence aggregate demand and promote economic stability. The effectiveness of fiscal policy also depends on its coordination with monetary policy (Caramp & Silva, 2023; Reichlin et al., 2022), the efficiency of government spending (Afonso & Alves, 2023), and the structure of the economy (Bouakez et al., 2023). Additionally, the effectiveness of fiscal policy is influenced by public debt levels and economic conditions. For instance, fiscal policy shocks result in higher multipliers and a stronger reduction in the public debt-to-GDP ratio during periods of high debt (Ciaffi et al., 2024). Furthermore, the balance between centralization and decentralization in fiscal policy implementation can impact its effectiveness in achieving economic goals (Afonso et al., 2024; Feng & Ge, 2024).

Fiscal policy is a powerful tool for managing aggregate demand, but its effects are complex and intertwined with other economic features. Understanding these complexities is crucial for policymakers aiming to use fiscal policy effectively to manage aggregate demand and promote economic stability and growth.

Monetary policy

Monetary policy involves central bank actions to regulate the money supply and interest rates, aiming to control inflation and foster economic stability. It influences aggregate demand by affecting interest rates and credit availability. Tools like adjusting the money supply and interest rates are globally employed to manage inflation (1, 2014). Tight monetary policy, through reduced money supply or higher interest rates, typically aims to lower inflation by decreasing aggregate demand. For example, Zhang (2019) showed that in China, real money balances could influence aggregate demand beyond short-term interest rate effects.

Monetary policy impacts aggregate demand in complex ways, influenced by economic conditions, policy implementation, and expectations. Its interaction with other economic variables necessitates careful design and implementation to achieve macroeconomic goals. It affects aggregate demand by altering borrowing costs and spending decisions (Belongia & Ireland, 2024; Caballero & Simsek, 2023). Expansionary policy, such as increasing the money supply or lowering interest rates, can stimulate demand by making borrowing cheaper, thereby encouraging spending and investment (Bissoondeeal et al., 2023; Ganguly & Acharyya, 2022). Conversely, contractionary policy can curb demand by making borrowing more expensive and encouraging saving (Bachmann et al., 2022). However, its impact on demand varies across economic sectors. For instance, a contractionary policy significantly reduces the Personal Consumption Expenditures Price Index (PCEPI) after three years, with varied timing and magnitude across price categories (Aruoba & Drechsel, 2024). This highlights the non-uniform impact of monetary policy on demand. Furthermore, monetary policy can impacts the supply side. Apergis and Miller (2007) found that monetary policy and its volatility can enhance total factor productivity, challenging the traditional view that it mainly affects demand.

The effectiveness of monetary policy is influenced by features like uncertainty, digital finance, and expectations. For example, monetary tightening might be counterproductive if cost-side effects dominate, particularly during cost-push inflation driven by high energy prices (Rehman, 2014). Adhering to the Taylor principle during normal times can reduce strategic complementarities among firms' pricing decisions, potentially making prices strategic substitutes (Cornand & Heinemann, 2019). However, in a liquidity trap or when the Taylor principle is violated, pricing decisions may remain strategic complements, complicating monetary policy transmission (Cornand & Heinemann, 2019). In economies with demand

inertia, it might be optimal to "run the economy hot" during temporary supply contractions, frontloading rate cuts to boost demand in anticipation of supply recovery (Caballero & Simsek, 2023). The events such as Brexit and Covid-19 have affected money demand functions, impacting policy transmission (Bissoondeeal et al., 2023). The expectations channel is also vital, as central bank communications shape inflation expectations and, consequently, aggregate demand (Goyal & Parab, 2023). However, monetary policy's effectiveness can be enhanced by, e.g., using Divisia monetary aggregates and considering uncertainty measures, especially in low-interest-rate environments (Belongia & Ireland, 2024; Bissoondeeal et al., 2023). Policymakers must also consider long-term impacts, as suboptimal policies can cause persistent effects on output and inflation (Fatás & Singh, 2023; Fornaro & Wolf, 2023).

Monetary policy is closely linked with fiscal policy in managing demand, especially in economies with heterogeneity, imperfect insurance, and nominal rigidity (Bilbiie et al., 2024). The interaction between monetary and fiscal policies creates a tradeoff between stabilization and redistribution, as fiscal-induced inequality changes can make flexible-price equilibrium suboptimal. This underscores the complexity of managing demand through monetary policy alone and the need for coordinated fiscal and monetary policies to achieve optimal economic outcomes.

While monetary policy is a potent tool for influencing aggregate demand, its effects are multifaceted, extending beyond simple demand management. Effective policy requires considering both demand- and supply-side effects, and potential asymmetries in its impact on different economic components (Khundrakpam, 2017). It operates mainly through adjustments in bank reserves and interest rates, impacting inflation, unemployment, and overall economic conditions (Belongia & Ireland, 2024; Caballero & Simsek, 2023).

In the empirical area, scholars found that retail sales are influenced by numerous features. It was found, for examples, that different retail categories experience varying influences, with income emerging as an important variable (Ferber, 1958). Population density, county size, interstate highway access, and lower farm reliance correlate with higher retail pull features (Jr, 1996). Consumer traits such as busyness, variety seeking, perceived financial wellness, market maven tendencies, and brand loyalty influence retail sales (Laroche et al., 2003). Additionally, demand-side features, including income elasticity, are vital in explaining structural changes in the retail industry, particularly in e-commerce growth (Ramcharran, 2013). In border regions, exchange rate fluctuations, international business cycles, and cross-border shopping contribute to retail activity (Fullerton & Walke, 2014). Seasonal changes, price reductions, and holidays significantly affect daily demand for fresh food products in retail stores (Arunraj et al., 2016). For non-metro cities, demographic, economic, locational, and business environment variables are critical determinants of retail sales (Walzer et al., 2018). Air pollution also impacts retail sales negatively, with a 0.1 percent reduction in monthly sales for each additional day of high PM10 levels (Kang et al., 2019).

Additionally, Li et al. (2020) identify features such as the number of reviews, star ratings, standard deviation of ratings, helpfulness, and sentiment as significant determinants of sales. Price discounts also impact sales, while product age and reviewer reputation moderate the relationship between online reviews and sales. Moreover, weather conditions substantially impact retail sales. Rose and Dolega (2021) demonstrate that wind is consistently the most influential weather condition, especially during summer and spring. Different product categories and store locations exhibit varying levels of weather sensitivity. Socioeconomic features and spatial competition between shops affect retail sales at the micro level. Retail performance also depends on spatial features, with the neighboring physical environment playing a crucial role (Sung, 2022). Additionally, physical environment and spatial features significantly affect retail sales. Sung (2022) highlights the importance of spatial dependence

and heterogeneity in retail performance analysis. Features such as neighboring retail areas and the interdependence between retail locations within a city-region impact sale. Store location is crucial, with geo-spatial and socio-demographic features influencing sales dynamics across different product categories (Formánek & Sokol, 2022). Content design and visual elements also determine retail sales. Püchel and Wellbrock (2022) reveal that color choice, text-image congruence, ease of cognitive processing, and promotional activities significantly influence sales in the magazine retail sector. Futhermore, Wang et al. (2022) find that nearby populations, road length, and non-commercial points of interest positively impact sales, while commercial facilities and geographic barriers can negatively affect them. The isolation and decentralization of shops within certain distances can also influence sales performance. Moreover, online reviews and motivating features play a role in product sales.

In addition, product variety plays a significant role in retail sales. Larger product assortments can increase sales by attracting a broader customer base or encouraging more frequent purchases. However, the impact of product variety differs between hedonic and utilitarian product categories (Sweeney et al., 2023). Sales efforts are crucial in driving revenue and increasing overall retail success. Dynamic sales efforts, combined with price-sensitive stochastic demand, can lead to higher profits in dual-channel (online and offline) retailing systems (Datta et al., 2023). The quality and depth of customer interactions also affect sales. For experience goods, the depth of answers in Q&A systems positively impacts sales. Fit- and quality-oriented questions, as well as positive and negative answers, have different effects on sales (Khern-Am-Nuai et al., 2023). Cumulative service encounters (CSE) can negatively impact sales staff performance, leading to lower conversions and sales. This effect is particularly noticeable within a single day (Chen & Chuang, 2023).

The retail environment itself plays a role in sales. Neighborhood-level retail areas have shown more resilience and faster recovery in sales compared to district-level retail areas, especially during disruptive events like the COVID-19 pandemic (Che et al., 2023). Additionally, the presence of retail services can be capitalized into residential property values, with frequently consumed and experiential retail services in mixed-use neighborhoods having a positive impact (Ghorbani & Meltzer, 2023). Other features affecting retail sales include the adoption of digital technologies (Silva et al., 2022), online retail service quality features such as reliability and ease of use (Singh et al., 2023), and shopping tourism, which can significantly impact retail sales and rents in popular shopping destinations (Yiu, 2023). Furthermore, economic features such as GDP growth, population increase, and consumer sentiment significantly influence retail sales. For instance, in the furniture industry, these features, along with housing starts and furniture imports, shape sales forecasts and demand patterns (İnce & Taşdemir, 2024).

From this knowledge, we can state that retail sales are influenced by a multifaceted interplay of features, including spatial characteristics, consumer behavior, environmental conditions, and economic indicators. Understanding these diverse influences can help retailers and policymakers optimize strategies to enhance sales performance and economic impact.

METHODOLOGY

This research compares the performance of three well-known models, namely Multiple Linear Regression (MLR), Artificial Neural Network (ANN), and K-Nearest Neighbors model (KNN), and makes the forecast for retail sales.

The multiple linear regression (MLR) model (Mata, 2011) presented in the paper is defined as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \text{ò}. \quad (1)$$

For the Artificial Neural Network (ANN) model (Khashei & Bijari, 2010) construct each neuron in the hidden layer and the output layer uses a weighted sum of the inputs and applies an activation function to produce an output. For neuron j in the hidden layer:

$$z_j = \sum_{i=1}^{7} w_{ij} x_i - \theta_j, \quad (2)$$

where x_i represents the features. w_{ij} represents the weight between the input and the neuron j. θ_j is the bias or threshold for neuron j. z_j is the weighted sum input to neuron j.

In this study, Sigmoid activation function $f(z_j) = \frac{1}{1+e^{-z_j}}$ is applied to the weighted sum z_j to produce the output of neuron j. The final predicted BCI can be modeled using the weighted sum of the hidden layer outputs as follows:

$$y = f\left(\sum_{j=1}^{n_h} w_j^{(h)} y_j - \theta_o \right), \quad (3)$$

where n_h is the number of neurons in the hidden layer. $w_j^{(h)}$ are the weights connecting the hidden layer neurons to the output neuron. y_j is the output from the j hidden layer neuron. θ_o is the bias or threshold for the output neuron. The representation of ANN is exhibit by Figure 1.

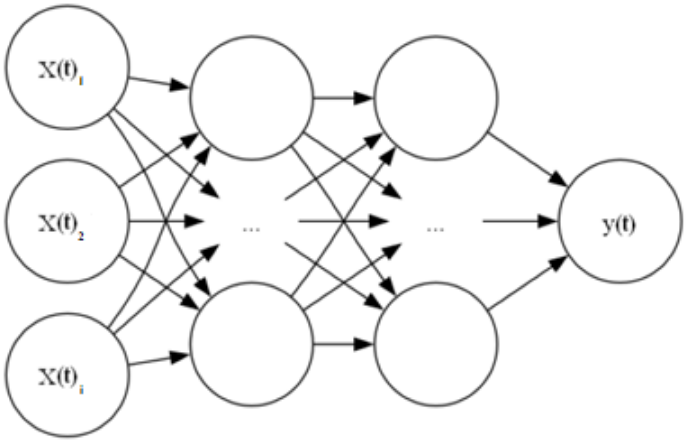


Figure 1 – ANN model

K-Nearest Neighbors model (KNN) can be derived as follows. Given a test sample $\mathbf{x}_{\text{test}}$, the KNN regressor performs the following steps:

Compute distances between the test sample and all training samples:

$$d(\mathbf{x}_{\text{test}}, \mathbf{x}_i) = \sqrt{\sum_{j=1}^{d} \left(x_{\text{test},j} - x_{i,j}\right)^2}, \quad (4)$$

This is the Euclidean distance between the test sample and a training sample $\mathbf{x}_i$. The step is to select K nearest neighbors ($K = 2$), which are the training points with the smallest distances. Then aggregate predictions using the mean of the K-nearest neighbors' target values:

$$\hat{y}_{\text{test}} = \frac{1}{K} \sum_{i \in \mathcal{N}_K} y_i, \quad (5)$$

where $\mathcal{N}_K$ is the set of the K nearest neighbors.

In this study, the model performance is indicated by Mean Absolute Percentage Error (MAPE) which is a statistical metric used to measure the accuracy of a forecasting model. This indicator can be written by:

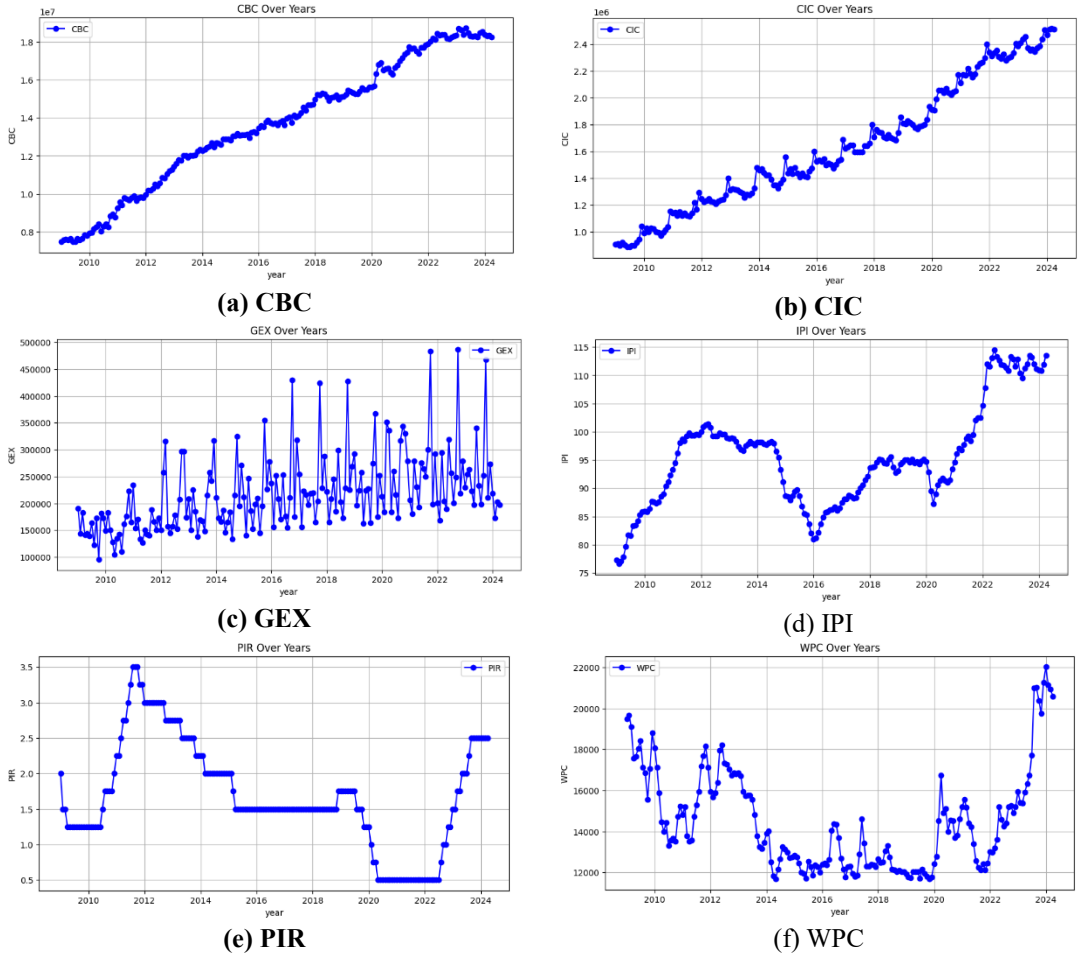
$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{A_i - F_i}{A_i}\right| \times 100, \tag{6}$$

where A_i is the actual value. F_i denotes the forecasted value. n is the number of observations

This study investigates key economic indicators, including Policy Interest Rate (PIR), Wholesale Price of Consumer Goods (WPC, proxied by rice prices), Commercial Bank Credit (CBC), Currency in Circulation (CIC), Government Expenditure (GEX), Import Price Index (IPI), and Retail Sales Index (REI, target). Utilizing monthly data from January 2009 to April 2024, sourced from the Bank of Thailand, the analysis was conducted using Python with bespoke code developed by the author.

RESULT

In this section, we present the results of our analysis aimed at forecasting retail sales using three models, i.e., Multiple Linear Regression (MLR), Artificial Neural Networks (ANN), and K-Nearest Neighbors (KNN). Figure 2 shows the data series of features.



(a) CBC **(b) CIC**

(c) GEX (d) IPI

(e) PIR (f) WPC

Figure 2 – Data series of features

Table 1 – multiple regression full model estimation

	coef	std err	t	P>|t|	[0.025	0.975]
const	52.122	1.847	28.222	0.000	48.477	55.767
PIR	17.901	3.069	5.832	0.000	11.843	23.958
WPC	- 8.877	2.932	- 3.028	0.003	- 14.663	- 3.091
CBC	13.339	10.115	1.319	0.189	- 6.621	33.300
CIC	35.097	11.650	3.013	0.003	12.107	58.088
GEX	5.883	3.001	1.960	0.052	- 0.040	11.806
IPI	11.256	3.792	2.968	0.003	3.772	18.740

The multiple regression analysis in Table 1 identifies significant features influencing the Retail Sales Index (REI). PIR shows a strong positive effect (coef: 17.901, $p < 0.001$), suggesting higher interest rates boost retail sales, while WPC has a negative impact (coef: -8.877, $p = 0.003$), implying that increased prices for consumer goods lower retail activity. CIC positively influences REI (coef: 35.097, $p = 0.003$), showing that more currency in circulation supports retail growth. IPI also exhibits a positive relationship (coef: 11.256, $p = 0.003$), indicating higher import prices correspond with increased retail sales. CBC and GEX show weaker effects, with non-significant and marginal significance, respectively. However, GEX is considered significant at a 10 percent level. Table 2 shows the multiple regression reduced model estimation

Table 2 – multiple regression reduced model estimation

	coef	std err	t	P>|t|	[0.025	0.975]
const	53.357	1.595	33.444	0.000	50.208	56.505
PIR	19.344	2.874	6.731	0.000	13.673	25.014
WPC	- 11.391	2.232	- 5.103	0.000	- 15.796	- 6.986
CIC	49.792	3.410	14.603	0.000	43.063	56.520
GEX	6.158	3.000	2.052	0.042	0.237	12.079
IPI	9.978	3.674	2.716	0.007	2.728	17.228

Table 3 – correlation analysis of selected features

	PIR	WPC	CIC	GEX	IPI	REI
PIR	1.000	0.375	- 0.430	- 0.250	0.184	- 0.129
WPC	0.375	1.000	- 0.010	- 0.143	0.296	- 0.028
CIC	- 0.430	- 0.010	1.000	0.473	0.652	0.867
GEX	- 0.250	- 0.143	0.473	1.000	0.222	0.459
IPI	0.184	0.296	0.652	0.222	1.000	0.730
REI	- 0.129	- 0.028	0.867	0.459	0.730	1.000

The correlation analysis in Table 3 explores relationships among the selected features and the Retail Sales Index (REI), e.g., CIC exhibits the strongest positive correlation with REI (0.867). IPI also shows a notable positive correlation with REI (0.730). The predicted values of the selected features using the ANN model are shown in equations (9) – (13), and the results are illustrated in Figures 3.

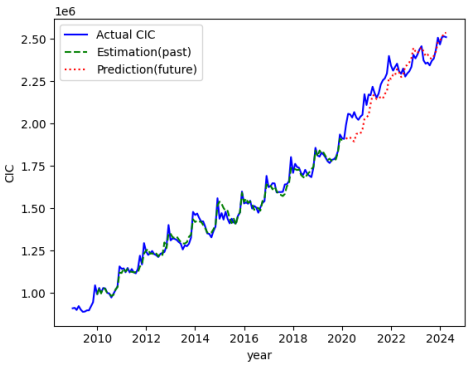
$$\mathrm{WPC}_t = \mathrm{f}(\mathrm{WPC}_{t-1}, \mathrm{WPC}_{t-2}, \mathrm{WPC}_{t-3}, \ldots, \mathrm{WPC}_{t-12}), \quad (9)$$

$$CIC_t = f(CIC_{t-1}, CIC_{t-2}, CIC_{t-3}, \dots, CIC_{t-12}), \quad (10)$$

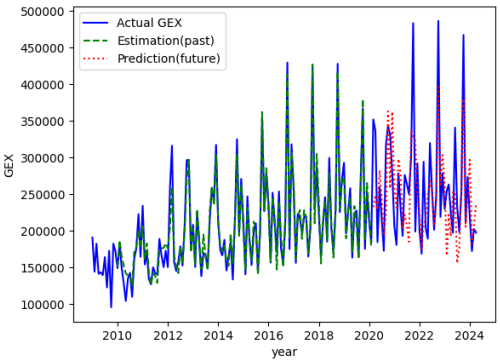
$$PIR_t = f(PIR_{t-1}, PIR_{t-2}, PIR_{t-3}), \quad (11)$$

$$IPI_t = f(IPI_{t-1}, IPI_{t-2}), \quad (12)$$

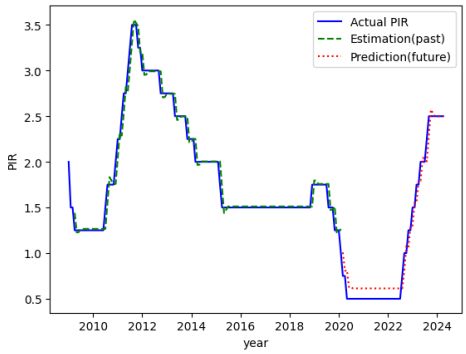
$$GEX_t = f(GEX_{t-1}, GEX_{t-2}), \quad (13)$$



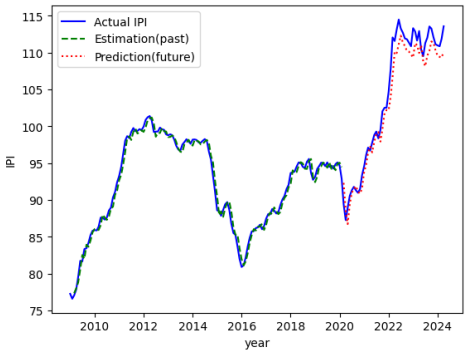
(a) CIC



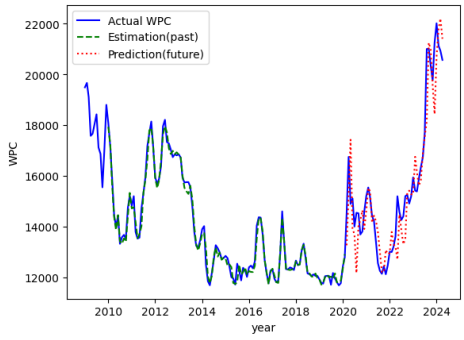
(b) GEX



(c) PIR



(d) PIP



(e) WPC

Figure 3 – ANN prediction for CIC, GEX, PIR, IPI, and WPC

Then, the ANN model, with 64 Input neurons and 32 hidden neurons, is used to predict REI which is expressed in Figure 4.

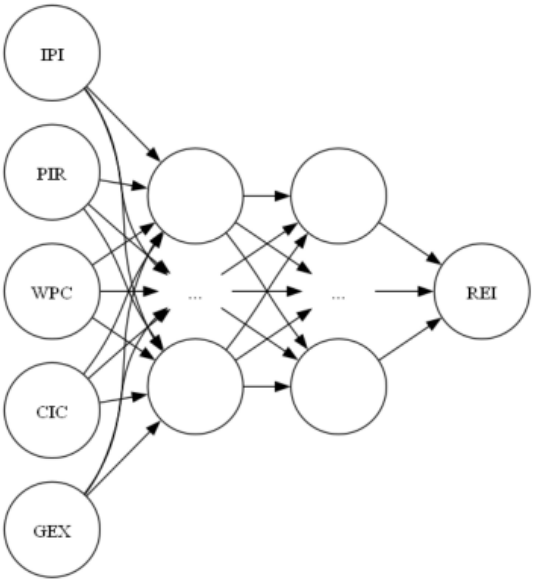
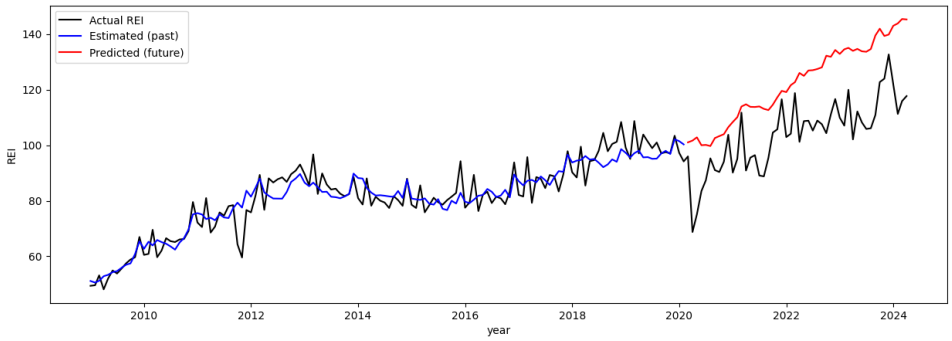
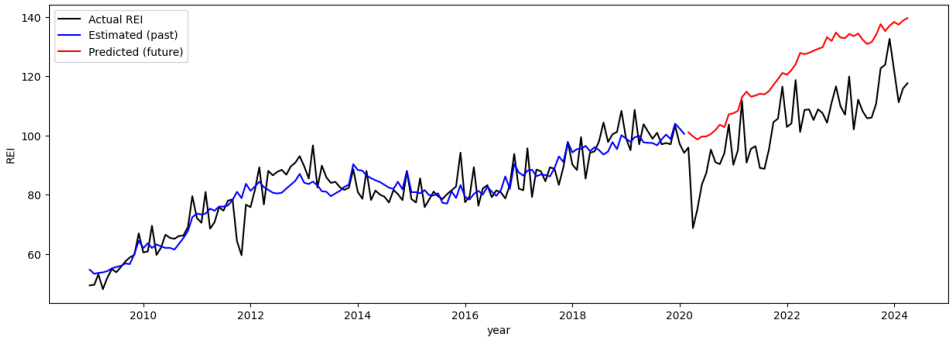


Figure 4 – ANN for REI prediction

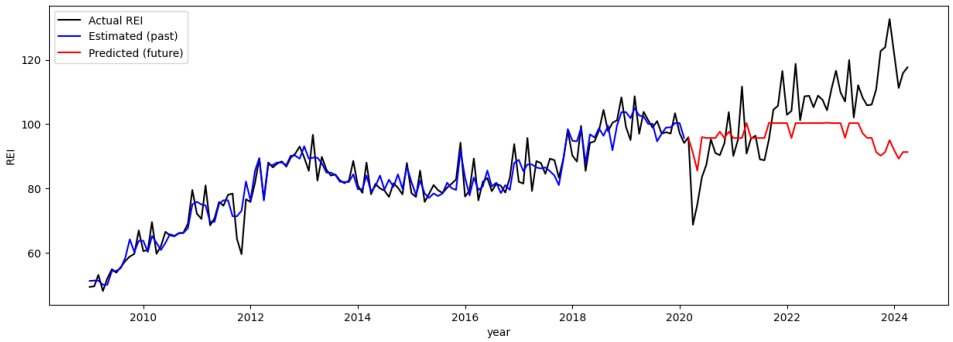
The REI prediction results from ANN, MLR, and KNN models are exhibited in Figure 5, and model performance indicated by Mean Absolute Percentage Error (MAPE) for comparison is presented in Table 4 which reveals that the K-Nearest Neighbors (KNN) model achieves the lowest MAPE (10.435), indicating superior forecasting accuracy compared to the other techniques. Figure 6 shows features forecast by ANN.



(a) ANN model



(b) MLR

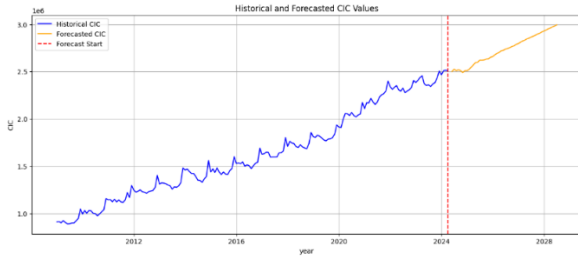


(c) KNN

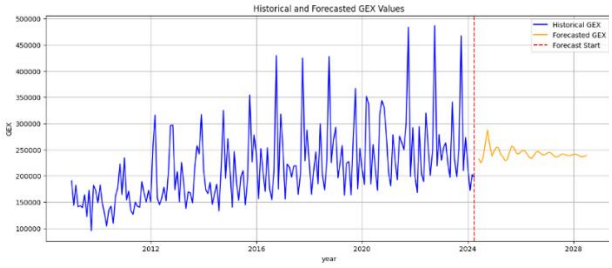
Figure 5 – REI prediction from ANN, MLR, and KNN

Table 4 – Model performance

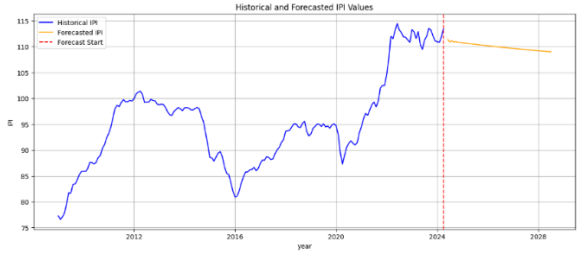
Model	Testing MAPE
ANN	22.491
MLR	17.719
KNN	10.435



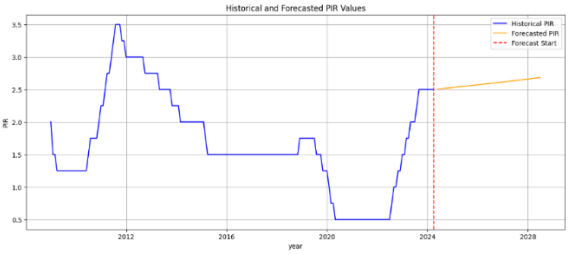
(a) CIC



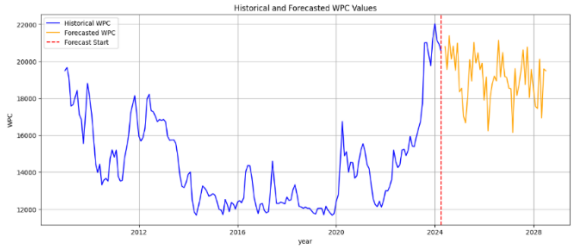
(b) GEX



(c) IPI



(d) PIR



(e) WPC

Figure 6 – features forecast by ANN

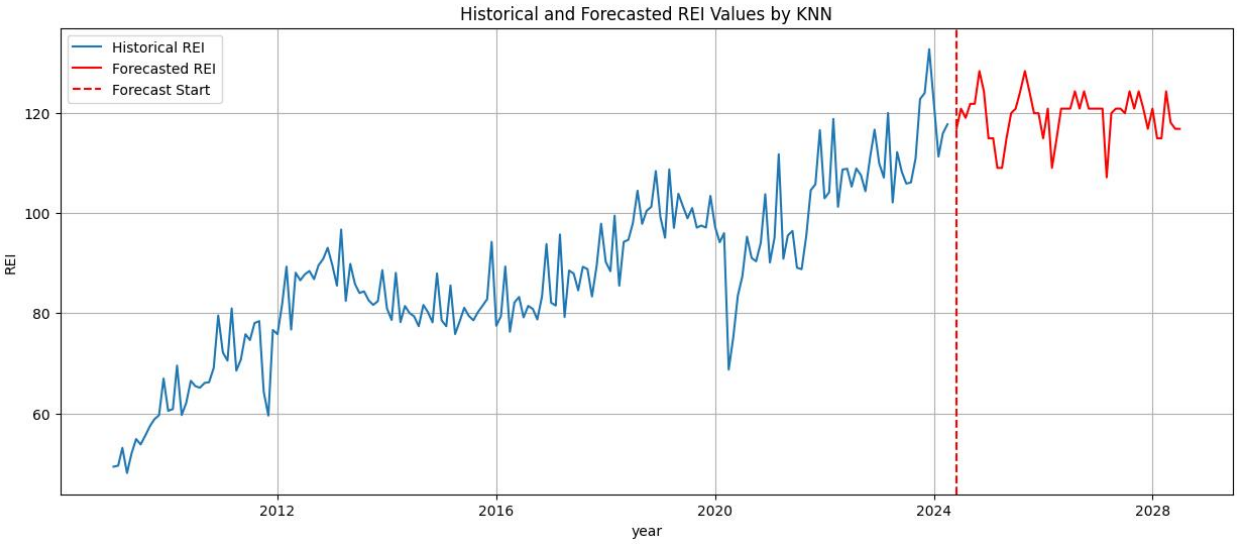


Figure 7 – forecast REI by KNN

Figure 7 illustrates the 5-year-ahead forecast of the Retail Sales Index (REI) using the K-Nearest Neighbors (KNN) model, showing the fluctuations in retail sales over time without trend.

DISCUSSION

The significant positive coefficient for PIR suggests that higher interest rates correlate with increased retail sales. This finding contradicts the principles of Demand Theory which traditional interpretation that higher interest rates typically dampen consumer spending. However, the context of this study suggests that, perhaps, in a growing economy, higher interest rates could be associated with increased consumer confidence and spending. This complexity reflects modern extensions of demand theory that consider broader economic contexts and consumer behaviour dynamics (Xu et al., 2023). Furthermore, the negative impact of the Wholesale Price of Consumer Goods (WPC) on retail sales reaffirms findings from previous studies that emphasize how price elasticity affects consumption patterns. Research indicates that consumers tend to reduce consumption of goods when prices rise, which is a fundamental aspect of Demand Theory (Rachlin et al., 1976). Also, this study corroborates previous studies that have illustrated how external economic features, including fiscal policy and pricing, can lead to significant variations in consumer behaviour (Pahari et al., 2023; Xu et al., 2023). The positive effect of GEX and CIC on retail sales (coefficient: 35.097) underscores the relationship between liquidity in the economy and consumer spending. This finding supports the government policy framework, which posits that government spending and monetary measures that enhance liquidity can stimulate consumer demand (Bilbiie et al., 2024). The results reinforce the idea that the effectiveness of these policies can create an environment conducive to retail sales growth.

POLICY IMPLICATION

The positive relationship between the Policy Interest Rate (PIR) and retail sales suggests that policymakers should consider maintaining favourable interest rates to stimulate consumer

spending. This could foster economic growth, particularly in periods of economic uncertainty. Additionally, the substantial impact of Currency in Circulation (CIC) and Government Expenditure (GEX) on retail sales underlines the importance of ensuring adequate liquidity in the economy. Policymakers should prioritize strategies that enhance money supply through effective fiscal and monetary measures, such as increasing money supply and targeted government spending, to bolster consumer confidence and purchasing power. Furthermore, the negative influence of the Wholesale Price of Consumer Goods (WPC) on retail activity indicates the need for policies that mitigate price increases, particularly in essential goods. This could involve monitoring market conditions and implementing price stabilization measures to protect consumers and ensure sustained retail growth.

FUTURE RESEARCH

Future research should investigate the long-term effects of interest rate fluctuations on consumer behaviour, considering different economic contexts and consumer segments. Additionally, examining the impact of digital transformation, particularly through e-commerce and AI technologies, on retail sales forecasting would be valuable. Moreover, expanding the geographic scope of the analysis to include diverse markets could provide comparative insights into retail performance across different economic environments.

CONCLUSION

Understanding the dynamics of retail sales is crucial, as this sector significantly influences business strategies and economic growth. This research aimed to forecast retail sales by utilizing traditional Multiple Linear Regression (MLR) and machine learning techniques, including Artificial Neural Networks (ANN), and K-Nearest Neighbors (KNN). The study utilized monthly data from January 2009 to April 2024 obtained from the Bank of Thailand. The features to be investigated include Policy Interest Rate (PIR), Wholesale Price of Consumer Goods (WPC, proxied by rice prices), Commercial Bank Credit (CBC), Currency in Circulation (CIC), Government Expenditure (GEX), Import Price Index (IPI), and Retail Sales Index (REI, target). This study compares the performance of these models based on their predictive accuracy, as measured by the Mean Absolute Percentage Error (MAPE). The results revealed that the KNN model outperformed the other model as it achieves the lowest MAPE which indicates superior predicting accuracy. The findings showed that PIR, CIC, and GEX play a critical role in supporting retail sales. Conversely, WPC negatively impacted retail sales. This study suggests that maintaining favorable interest rates can stimulate consumer spending in the retail sector. Additionally, ensuring adequate liquidity through effective monetary and fiscal measures can bolster retail sales. The negative impact of WPC on retail sales highlights the need for strategies to stabilize prices to protect retail sales.

ACKNOWLEDGEMENT

This research is supported by the School of Economics, Sukhothai Thammathirat Open University, Thailand. This research is also supported by the computer engineering department Srinakharinwirot University, Nakhon Nayok, Thailand.

REFERENCES

Mata, J. (2011). Interpretation of concrete dam behaviour with artificial neural network and multiple linear regression models. *Engineering Structures, 33*(3), 903–910. https://doi.org/10.1016/j.engstruct.2010.12.011

İnce, M. N., & Taşdemir, Ç. (2024). Forecasting Retail Sales for Furniture and Furnishing Items through the Employment of Multiple Linear Regression and Holt–Winters Models. Systems, 12(6), 219. https://doi.org/10.3390/systems12060219

Ramadan, A., & Morshed, A. (2024). Optimizing retail prosperity: Strategic working capital management and its impact on the global economy. Journal of Infrastructure, Policy and Development, 8(5), 3827. https://doi.org/10.24294/jipd.v8i5.3827

Khern-Am-Nuai, W., Ghasemkhani, H., Qiao, D., & Kannan, K. (2023). The Impact of Online Q&As on Product Sales: The Case of Amazon Answer. Information Systems Research, 35(2), 747–765. https://doi.org/10.1287/isre.2023.1233

Datta, A., Sarkar, B., Dey, B. K., Sangal, I., Yang, L., Fan, S.-K. S., Sardar, S. K., & Thangavelu, L. (2023). The impact of sales effort on a dual-channel dynamical system under a price-sensitive stochastic demand. Journal of Retailing and Consumer Services, 76, 103561. https://doi.org/10.1016/j.jretconser.2023.103561

Chen, C.-M., & Chuang, H. H.-C. (2023). Time to shift the shift: Performance effects of within-day cumulative service encounters in retail stores. Omega, 119, 102892. https://doi.org/10.1016/j.omega.2023.102892

Che, J., Lee, J. S., & Kim, S. (2023). How has COVID-19 impacted the economic resilience of retail clusters?: Examining the difference between neighborhood-level and district-level retail clusters. Cities, 140, 104457. https://doi.org/10.1016/j.cities.2023.104457

Singh, S., Misra, R., Jasial, S. S., & Bansal, A. (2023). Online Retail Service Quality: What Matters Most for Customer Satisfaction? FIIB Business Review, 13(5), 600–615. https://doi.org/10.1177/23197145231151736

Silva, P. M., Santos, J. F., & Moutinho, V. F. (2022). Salespeople's performance and digital technologies in real estate: Evidence from the Portuguese retail real estate sector. Journal of General Management, 49(1), 18–31. https://doi.org/10.1177/03063070221117265

Yiu, C. Y. (2023). The Impacts of Shopping Tourism on Retail Sales and Rents: Lessons from the COVID-19 Quasi-Experiment of Hong Kong. Journal of Risk and Financial Management, 16(6), 301. https://doi.org/10.3390/jrfm16060301

Ghorbani, P., & Meltzer, R. (2023). Are local retail services an amenity or a nuisance? Journal of Economic Geography, 24(2), 193–218. https://doi.org/10.1093/jeg/lbad034

Sweeney, K., Duan, Y., Evers, P. T., & Windle, R. (2023). Trade-offs between operational performance and sales in a retail environment: The simultaneous impact of product variety on inventory levels, product availability, and sales. Journal of Business Logistics, 44(3), 463–479. https://doi.org/10.1111/jbl.12334

Sung, H. (2022). Estimating the spatial impact of neighboring physical environments on retail sales. Cities, 123, 103579. https://doi.org/10.1016/j.cities.2022.103579

Püchel, L., & Wellbrock, C.-M. (2022). Judging A Magazine by Its Cover – A Conceptual Framework to Understand Sales Through Content and Design Interaction. International Journal on Media Management, 24(2), 87–116. https://doi.org/10.1080/14241277.2022.2089990

Formánek, T., & Sokol, O. (2022). Location effects: Geo-spatial and socio-demographic determinants of sales dynamics in brick-and-mortar retail stores. Journal of Retailing and Consumer Services, 66, 102902. https://doi.org/10.1016/j.jretconser.2021.102902

Rose, N., & Dolega, L. (2021). It\u2019s the Weather: Quantifying the Impact of Weather on Retail Sales. Applied Spatial Analysis and Policy, 15(1), 189–214. https://doi.org/10.1007/s12061-021-09397-0

Wang, W., Wang, Y., Wang, X., & Wang, L. (2022). Geographical Determinants of Regional Retail Sales: Evidence from 12,500 Retail Shops in Qiannan County, China. ISPRS International Journal of Geo-Information, 11(5), 302. https://doi.org/10.3390/ijgi11050302

Li, K., Chen, Y., & Zhang, L. (2020). Exploring the influence of online reviews and motivating features on sales: A meta-analytic study and the moderating role of product category. Journal of Retailing and Consumer Services, 55, 102107. https://doi.org/10.1016/j.jretconser.2020.102107

Arunraj, N. S., Ahrens, D., & Fernandes, M. (2016). Application of SARIMAX Model to Forecast Daily Sales in Food Retail Industry. International Journal of Operations Research and Information Systems, 7(2), 1–21. https://doi.org/10.4018/ijoris.2016040101

Kang, H., Yu, J., & Suh, H. (2019). Does Air Pollution Affect Consumption Behavior? Evidence from Korean Retail Sales*. Asian Economic Journal, 33(3), 235–251. https://doi.org/10.1111/asej.12185

Ferber, R. (1958). Variations in Retail Sales between Cities. Journal of Marketing, 22(3), 295–303. https://doi.org/10.1177/002224295802200307

Sung, H. (2022). Estimating the spatial impact of neighboring physical environments on retail sales. Cities, 123, 103579. https://doi.org/10.1016/j.cities.2022.103579

Fullerton, T. M., & Walke, A. G. (2014). Homicides, exchange rates, and northern border retail activity in Mexico. The Annals of Regional Science, 53(3), 631–647. https://doi.org/10.1007/s00168-014-0636-y

Walzer, N., Blanke, A., & Evans, M. (2018). Features affecting retail sales in small and mid-size cities. Community Development, 49(4), 469–484. https://doi.org/10.1080/15575330.2018.1474238

Laroche, M., Pons, F., Zgolli, N., Cervellon, M.-C., & Kim, C. (2003). A model of consumer response to two retail sales promotion techniques. Journal of Business Research, 56(7), 513–522. https://doi.org/10.1016/s0148-2963(01)00249-1

Ramcharran, H. (2013). E-Commerce Growth and the Changing Structure of the Retail Sales Industry. International Journal of E-Business Research, 9(2), 46–60. https://doi.org/10.4018/jebr.2013040104

Aruoba, S. B., & Drechsel, T. (2024). The long and variable lags of monetary policy: Evidence from disaggregated price indices. Journal of Monetary Economics, 103635. https://doi.org/10.1016/j.jmoneco.2024.103635

Bilbiie, F. O., Monacelli, T., & Perotti, R. (2024). Stabilization vs. Redistribution: The optimal monetary–fiscal mix. Journal of Monetary Economics, 103623. https://doi.org/10.1016/j.jmoneco.2024.103623

Bissoondeeal, R. K., Binner, J. M., & Karoglou, M. (2023). The impact of uncertainty on money demand in the UK, US and Euro area. The European Journal of Finance, 29(16), 1866–1884. https://doi.org/10.1080/1351847x.2023.2204194

Belongia, M. T., & Ireland, P. N. (2024). The transmission of monetary policy shocks through the markets for reserves and money. Journal of Macroeconomics, 80, 103590. https://doi.org/10.1016/j.jmacro.2024.103590

Fatás, A., & Singh, S. R. (2023). Supply or demand? Policy makers' confusion in the presence of hysteresis. European Economic Review, 161, 104617. https://doi.org/10.1016/j.euroecorev.2023.104617

Ganguly, S., & Acharyya, R. (2022). Money, exchange rate and export quality. The Journal of International Trade & Economic Development, 33(1), 118–144. https://doi.org/10.1080/09638199.2022.2159059

Caballero, R. J., & Simsek, A. (2023). A Note on Temporary Supply Shocks with Aggregate Demand Inertia. American Economic Review: Insights, 5(2), 241–258. https://doi.org/10.1257/aeri.20220109

Goyal, A., & Parab, P. (2023). Working of Expectations Channel of Monetary Policy Transmission in India. Journal of International Commerce, Economics and Policy, 14(02). https://doi.org/10.1142/s1793993323500126

Bachmann, R., Gödl-Hanisch, I., & Sims, E. R. (2022). Identifying monetary policy shocks using the central bank's information set. Journal of Economic Dynamics and Control, 145, 104555. https://doi.org/10.1016/j.jedc.2022.104555

Fornaro, L., & Wolf, M. (2023). The scars of supply shocks: Implications for monetary policy. Journal of Monetary Economics, 140, S18–S36. https://doi.org/10.1016/j.jmoneco.2023.04.003

Cornand, C., & Heinemann, F. (2019). Monetary policy obeying the Taylor principle turns prices into strategic substitutes. Journal of Economic Behavior & Organization, 200, 1357–1371. https://doi.org/10.1016/j.jebo.2019.10.022

Belongia, M. T., & Ireland, P. N. (2024). The transmission of monetary policy shocks through the markets for reserves and money. Journal of Macroeconomics, 80, 103590. https://doi.org/10.1016/j.jmacro.2024.103590

Caballero, R. J., & Simsek, A. (2023). A Note on Temporary Supply Shocks with Aggregate Demand Inertia. American Economic Review: Insights, 5(2), 241–258. https://doi.org/10.1257/aeri.20220109

Goyal, A., & Parab, P. (2023). Working of Expectations Channel of Monetary Policy Transmission in India. Journal of International Commerce, Economics and Policy, 14(02). https://doi.org/10.1142/s1793993323500126

Rehman, A. (2014). Relationship Between Energy Prices, Monetary Policy and Inflation; A Case Study of South Asian Economies. (2014). Journal of Central Banking Theory and Practice, 3(1), 43–58. https://doi.org/10.2478/jcbtp-2014-0004

Apergis, N., & Miller, S. M. (2007). Total Factor Productivity and Monetary Policy: Evidence from Conditional Volatility*. International Finance, 10(2), 131–152. https://doi.org/10.1111/j.1468-2362.2007.00200.x

Zhang, G. (2019). Optimal Monetary Policy in China with Money as Not Redundant. Australian Economic Review, 52(3), 294–304. https://doi.org/10.1111/1467-8462.12323

Khundrakpam, J. K. (2017). Examining the Asymmetric Impact of Monetary Policy in India. Margin: The Journal of Applied Economic Research, 11(3), 290–314. https://doi.org/10.1177/0973801017703500

Bilbiie, F. O., Monacelli, T., & Perotti, R. (2024). Stabilization vs. Redistribution: The optimal monetary–fiscal mix. Journal of Monetary Economics, 103623. https://doi.org/10.1016/j.jmoneco.2024.103623

Khalid, M., Sattar, A., & Malik, W. S. (2024). The Fiscal Reaction Function and the Transmission Mechanism for Pakistan. The Pakistan Development Review, 46(4II), 435–447. https://doi.org/10.30541/v46i4iipp.435-447

Ciaffi, G., Deleidi, M., & Capriati, M. (2024). Government spending, multipliers, and public debt sustainability: an empirical assessment for OECD countries. Economia Politica, 41(2). https://doi.org/10.1007/s40888-024-00335-0

Feng, N., & Ge, J. (2024). How does fiscal policy affect the green low-carbon transition from the perspective of the evolutionary game? Energy Economics, 134, 107578. https://doi.org/10.1016/j.eneco.2024.107578

Afonso, A., Tovar Jalles, J., & Venâncio, A. (2024). Fiscal decentralization and public sector efficiency: Do natural disasters matter? Economic Modelling, 137, 106763. https://doi.org/10.1016/j.econmod.2024.106763

Parui, P. (2023). Fiscal expansion, government debt and economic growth: a post-Keynesian perspective. Journal of Post Keynesian Economics, 47(1), 117–154. https://doi.org/10.1080/01603477.2023.2221444

Caramp, N., & Silva, D. H. (2023). Fiscal policy and the monetary transmission mechanism. Review of Economic Dynamics, 51, 716–746. https://doi.org/10.1016/j.red.2023.08.001

Bilbiie, F. O., Monacelli, T., & Perotti, R. (2024). Stabilization vs. Redistribution: The optimal monetary–fiscal mix. Journal of Monetary Economics, 103623. https://doi.org/10.1016/j.jmoneco.2024.103623

Reichlin, L., Ricco, G., & Tarbé, M. (2022). Monetary–fiscal crosswinds in the European Monetary Union. European Economic Review, 151, 104328. https://doi.org/10.1016/j.euroecorev.2022.104328

Boug, P., Brasch, T. V., Cappelen, Å., Hammersland, R., Hungnes, H., Kolsrud, D., Skretting, J., Strøm, B., & Vigtel, T. C. (2023). Fiscal policy, macroeconomic performance and industry structure in a small open economy. Journal of Macroeconomics, 76, 103524. https://doi.org/10.1016/j.jmacro.2023.103524

Afonso, A., & Alves, J. (2023). Does government spending efficiency improve fiscal sustainability? European Journal of Political Economy, 102403. https://doi.org/10.1016/j.ejpoleco.2023.102403

Bouakez, H., Rachedi, O., & Santoro, E. (2023). The Government Spending Multiplier in a Multisector Economy. American Economic Journal: Macroeconomics, 15(1), 209–239. https://doi.org/10.1257/mac.20200213

Parui, P. (2023). Fiscal expansion, government debt and economic growth: a post-Keynesian perspective. Journal of Post Keynesian Economics, 47(1), 117–154. https://doi.org/10.1080/01603477.2023.2221444

Obst, T., Onaran, Ö., & Nikolaidi, M. (2020). The effects of income distribution and fiscal policy on aggregate demand, investment and the budget balance: the case of Europe. Cambridge Journal of Economics, 44(6), 1221–1243. https://doi.org/10.1093/cje/bez045

Cook, D., & Devereux, M. B. (2019). Fiscal Policy in a Currency Union at the Zero Lower Bound. Journal of Money, Credit and Banking, 51(S1), 43–82. https://doi.org/10.1111/jmcb.12666

Honda, J., & Miyamoto, H. (2021). How does population aging affect the effectiveness of fiscal stimulus over the business cycle? Journal of Macroeconomics, 68, 103288. https://doi.org/10.1016/j.jmacro.2021.103288

Chugunov, I., Pasichnyi, M., Kaneva, T., Koroviy, V., & Nikitishin, A. (2021). Fiscal and Monetary Policy of Economic Development. European Journal of Sustainable Development, 10(1), 42. https://doi.org/10.14207/ejsd.2021.v10n1p42

Bilbiie, F. O., Monacelli, T., & Perotti, R. (2024). Stabilization vs. Redistribution: The optimal monetary–fiscal mix. Journal of Monetary Economics, 103623. https://doi.org/10.1016/j.jmoneco.2024.103623

Cashin, D., Lenney, J., Lutz, B., & Peterman, W. (2018). Fiscal policy and aggregate demand in the USA before, during, and following the Great Recession. International Tax and Public Finance, 25(6), 1519–1558. https://doi.org/10.1007/s10797-018-9497-0

Cook, D., & Devereux, M. B. (2011). Cooperative fiscal policy at the zero lower bound. Journal of The Japanese and International Economies, 25(4), 465–486. https://doi.org/10.1016/j.jjie.2011.09.002

Fatás, A., & Mihov, I. (2012). Fiscal Policy as a Stabilization Tool. The B.E. Journal of Macroeconomics, 12(3). https://doi.org/10.1515/1935-1690.113

Baltaci, D. Ç., Durmaz, Y., & Baltaci, F. (2024). The relationships between the multidimensional planned behavior model, green brand awareness, green marketing activities, and purchase intention. Brain and Behavior, 14(6). https://doi.org/10.1002/brb3.3584

Alam, S. S., Lin, C.-Y., Ho, Y.-H., & Ahmed, S. (2024). Predicting Eco-labeled Product Buying Behavior in an Emerging Economy through an Extension of Theory of Planned Behavior. Revista de Gestão Social e Ambiental, 18(9), e6220. https://doi.org/10.24857/rgsa.v18n9-039

Xu, Q., He, Y., & Shao, Z. (2023). Retailer's ordering decisions with consumer panic buying under unexpected events. International Journal of Production Economics, 266, 109032. https://doi.org/10.1016/j.ijpe.2023.109032

Pahari, S., Prasad, B., Ghosal, I., & Dildar, S. M. (2023). Which Determinants Impact Consumer Purchase Behavior Toward Online Purchasing of Organic Food Products? Prabandhan: Indian Journal of Management, 16(1), 25. https://doi.org/10.17010/pijom/2023/v16i1/172667

Liu, Y., Li, X., & Yuen, K. F. (2023). Revenge buying: The role of negative emotions caused by lockdowns. Journal of Retailing and Consumer Services, 75, 103523. https://doi.org/10.1016/j.jretconser.2023.103523

Dangi, A., Singh, V., Saini, C. P., & Hooda, J. (2021). Customer perception, purchase intention and buying decision for branded products: measuring the role of price discounts. Journal of Revenue and Pricing Management, 20(2), 194–203. https://doi.org/10.1057/s41272-021-00300-7

Aljanabi, A. R. A. (2021). The impact of economic policy uncertainty, news framing and information overload on panic buying behavior in the time of COVID-19: a conceptual exploration. International Journal of Emerging Markets, 18(7), 1614–1631. https://doi.org/10.1108/ijoem-10-2020-1181

Jackson, L. F. (1984). Hierarchic Demand and the Engel Curve for Variety. The Review of Economics and Statistics, 66(1), 8. https://doi.org/10.2307/1924690

Mason, R. S. (1983). The Economic Theory of Conspicuous Consumption. International Journal of Social Economics, 10(3), 3–17. https://doi.org/10.1108/eb013935

Crozier, D. A., & Mclean, F. (1997). Consumer Decision-Making in the Purchase of Estate Agency Services. The Service Industries Journal, 17(2), 278–293. https://doi.org/10.1080/02642069700000016

Rachlin, H., Battalio, R. C., Green, L., & Kagel, J. H. (1976). Economic Demand Theory and Psychological Studies of Choice. In Psychology of Learning and Motivation (Vol. 10, pp. 129–154). https://doi.org/10.1016/s0079-7421(08)60466-1

Azad, M. S., Hossain, R., Khan, S. S., Rahman, R., & Momen, S. (2023). Predictive modeling of consumer purchase behavior on social media: Integrating theory of planned behavior and machine learning for actionable insights. PLOS ONE, 18(12), e0296336. https://doi.org/10.1371/journal.pone.0296336

Gripsrud, G., & Horverak, Ø. (1986). Determinants of retail patronage. A 'natural' experiment. International Journal of Research in Marketing, 3(4), 263–272. https://doi.org/10.1016/0167-8116(86)90006-6

Benjamin, J. D., Jud, G. D., & Okoruwa, A. A. (1993). Forecasting the stock of retail space using the Koyck distributed lag model. Journal of Property Research, 10(3), 185–192. https://doi.org/10.1080/09599919308724092

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting Impacts on Retail Sales Performance. Journal of the Illuminating Engineering Society, 31(2), 21–25. https://doi.org/10.1080/00994480.2002.10748389

Wang, Z., Ye, C., Liu, X., Ma, R., Sun, Z., & Ruan, J. (2022). Optimal retail sales strategies for old and new products in monopoly and horizontal competition scenarios. Journal of Retailing and Consumer Services, 71, 103218. https://doi.org/10.1016/j.jretconser.2022.103218

Maican, F., & Orth, M. (2021). Determinants of economies of scope in retail. International Journal of Industrial Organization, 75, 102710. https://doi.org/10.1016/j.ijindorg.2021.102710

Wohllebe, A., Dirrler, P., & Podruzsik, S. (2020). Mobile Apps in Retail: Determinants of Consumer Acceptance – A Systematic Review. International Journal of Interactive Mobile Technologies (IJIM), 14(20), 153. https://doi.org/10.3991/ijim.v14i20.18273

Channa, N. A., Bhutto, M., Tariq, B., Bhutto, M. H., & Bhutto, N. A. (2020). Capturing customer's store loyalty through relationship benefits: moderating effect of retail innovation. European Business Review, 34(1), 20–40. https://doi.org/10.1108/ebr-09-2019-0179

Liu, C., Xie, W., Wu, W.-Z., & Zhu, H. (2021). Predicting Chinese total retail sales of consumer goods by employing an extended discrete grey polynomial model. Engineering Applications of Artificial Intelligence, 102, 104261. https://doi.org/10.1016/j.engappai.2021.104261

Cruz Roche, I., Sellers-Rubio, R., & Romero, J. (2019). Retail services efficiency: impact of country-specific features. International Journal of Retail & Distribution Management, 47(8), 774–792. https://doi.org/10.1108/ijrdm-12-2018-0275

Tran, T. T. N. (2023). Sustainability of Traditional Retail in an Emerging Market: A Conceptual Framework Applied to a Vietnamese Wet Market. Asia Marketing Journal, 24(4), 143–151. https://doi.org/10.53728/2765-6500.1598

Malhotra, G., & Ramalingam, M. (2023). Perceived anthropomorphism and purchase intention using artificial intelligence technology: examining the moderated effect of trust. Journal of Enterprise Information Management. https://doi.org/10.1108/jeim-09-2022-0316

Rippé, C. B., Weisfeld-Spolter, S., Dubinsky, A. J., Arndt, A. D., & Thakkar, M. (2016). Selling in an asymmetric retail world: perspectives from India, Russia, and the US on buyer–seller information differential, perceived adaptive selling, and purchase intention. Journal of Personal Selling & Sales Management, 36(4), 344–362. https://doi.org/10.1080/08853134.2016.1215923

Wang, S., & Jones, K. (2001). CHINA'S RETAIL SECTOR IN TRANSITION. Asian Geographer, 20(1–2), 25–51. https://doi.org/10.1080/10225706.2001.9684074

Wang, E., & Song, J. (2008). The Political Economy of Retail Change in Chinese Cities. Environment and Planning C: Government and Policy, 26(6), 1197–1226. https://doi.org/10.1068/c0773b

Klaesson, J., & Öner, Ö. (2014). Market Reach for Retail Services. Review of Regional Studies, 44(2). https://doi.org/10.52324/001c.8077

TESTING COINTEGRATION BETWEEN STOCK MARKET RETURNS AND SELECTED TECHNOLOGY STOCK RETURNS WITH STRUCTURAL BREAKS

Saowakhon Nookhao[A], Adirek Vajrapatkul[B]

ABSTRACT

This study examines the cointegration between stock market returns and selected technology stocks, emphasizing the role of structural breaks. The research employs the Gregory-Hansen Cointegration Test to analyze regime shifts in the long-term relationship between variables, offering a refined approach compared to traditional cointegration tests. Using daily data from Yahoo Finance spanning from July 29, 2019, to July 26, 2024, the study includes the NASDAQ Composite Index and stocks from Microsoft Corporation (MSFT), NVIDIA Corporation (NVDA), and Broadcom Inc. (AVGO). The results of the Gregory-Hansen test indicate that the relationship between NASDAQ and the technology stocks shows stronger evidence of cointegration when accounting for regime changes, suggesting that structural breaks significantly influence market dynamics. The Error Correction Model (ECM) findings reveal that NASDAQ adjusts slowly to long-term equilibrium, with short-term effects prominent for MSFT and AVGO. Additionally, the study demonstrates that models without structural breaks provide weaker long-term relationships, highlighting the importance of accounting for these shifts in market behavior. The implications of these findings suggest that policymakers, investors, and financial analysts must consider structural breaks in their models to enhance market risk assessments, forecasting, and the development of robust investment strategies.

Keywords: *Stock Market, Technology Stocks, Cointegration, Structural Break, Error Correction Model, Gregory-Hansen Test*

INTRODUCTION

The stock market index is a pivotal indicator reflecting a country's economy's overall performance and health. Serving as a barometer of economic development, it is influenced by many social, environmental, and political factors (Mai et al., 2023). Stock market indices aggregate the performance of a group of stocks, offering investors a snapshot of market trends and enabling comparisons across different periods and economies. The significance of stock market indices lies in their capacity to offer valuable insights for investors, policymakers, and researchers. They are instrumental in forecasting future stock prices, selecting stocks, and optimizing portfolios (Solares et al., 2022). Additionally, stock market indices play a crucial role in global financial markets, with information flow between different economies' stock markets exerting mutual influence (Xie et al., 2021). This interconnectedness is particularly evident during major financial events, highlighting the close relationships between global stock indices.

By examining the relationship between the stock market and some variables, e.g., macroeconomic variables, researchers can gain critical insights into how economic factors

impact market performance. For instance, category-specific economic policy uncertainty indices have been shown to predict stock market returns (Zeng et al., 2022). Research in Malaysia found long-term relationships between macroeconomic variables and the stock market index, noting that the index responded negatively to money supply, inflation, and the producer price index, but positively to exchange rates (Mohnot et al., 2023). This information helps policymakers make informed decisions about economic policies. Also, analyzing stock market indices and related variables improves risk assessment and prediction capabilities. For instance, a study on China's stock market developed an early warning system using various indicators, including macroeconomic factors, to predict market risk (Chen et al., 2023). Such systems assist investors and regulators in anticipating and mitigating potential market risks.

Investigating the relationship between stock market indices and stock prices offers several benefits. This examination provides deep insights into market dynamics and investor behavior, elucidating how individual stock prices influence and are influenced by broader market trends. However, the relationship between stock market indices and individual stock prices is not always straightforward. While indices generally reflect overall market trends, individual stocks can be influenced by various factors that influence the stock market. Nevertheless, the investigation of the relationship between them is limited, i.e., several studies often investigate the relationship between the stock market and other variables. For instance, Aumeboonsuke (2020) employed Vector Autoregressive (VAR) analysis to examine both long-run and short-run impacts of commodity prices on stock indices. Chang and Fang (2022) utilized the Autoregressive Distributed Lag (ARDL) model and Granger causality tests to explore the relationship between natural resource commodity indices and stock market indices in China. Yılmaz and Güzel (2021) used the panel GMM estimation method to study the effect of exchange rates on stock market indices across four main sectors in Turkey. Vrînceanu et al. (2020) applied a two-stage GARCH (1,1) model and Granger causality test to investigate the relationship between oil price fluctuations and renewable energy stock returns. Mohnot et al. (2023) used vector autoregression (VAR) models and impulse response functions (IRF) to assess the impact of macroeconomic variables on stock market indices.

Structural breaks become a significant concern in this research area when investigating stock market relationships and behavior, as they can impact market behavior and investment strategies. For instance, Osabuohien-Irabor (2020) demonstrates that structural breaks influence the mean-reversion properties of stock prices, affecting investors' ability to predict market movements and develop trading strategies. Furthermore, Just and Echaust (2020) employ a two-regime Markov switching model to identify structural breaks between stock market returns and key market indicators, revealing the impact on the dependence between returns and implied volatility and implied correlation.

This research is motivated by the complex relationship between stock market indices and individual technology stock prices, which are not always straightforward due to the influence of various economic, social, environmental, and political factors. While stock market indices serve as significant indicators, the specific interplay between stock indices and individual stocks, particularly technology stocks, is not thoroughly understood. Prior research has focused extensively on the relationship between stock markets and macroeconomic variables. However, few studies have investigated the cointegration between stock indices and individual technology stock prices, especially when structural breaks exist. Therefore, this research aims to fill the gap by exploring the cointegration between NASDAQ and key technology stocks while accounting for structural breaks. The remaining sections of this research are organized as follows. The second section will explore pertinent concepts related to this research. Section 3 will outline the research methodology employed in this study.

Subsequently, the results of the analysis and discussions will be presented.

LITERATURE REVIEW

This section reviews existing literature on the impact of structural breaks and long-term relationships between market indices and individual stock prices. These insights provide a foundation for our study's methodology and analysis.

Structural breaks

Structural breaks represent significant changes in the underlying patterns or relationships within time series data. These disruptions can manifest in various aspects of financial and economic data, such as volatility, mean, or trend (Cappelli et al., 2020; Check& Piger, 2021). Detecting and analyzing structural breaks is crucial for several reasons. In financial markets, structural breaks can influence investor sentiment (Ballinari & Behrendt, 2020), affect volatility transmission between markets (Caporin & Malik, 2019), and alter hedge ratios (Caporin & Malik, 2019). In macroeconomic time series, structural breaks may indicate changes in persistence, variance parameters, and trend growth rates (Check & Piger, 2021). Furthermore, structural breaks can occur in the factor loadings of asset pricing models (Ma & Tu, 2022) and in the long memory properties of price and volume series (Patil & Rastogi, 2020).

If not properly accounted for, structural breaks can lead to spurious results. For example, structural breaks in volatility can cause misleading volatility transmission between independently generated return series (Caporin & Malik, 2019). Additionally, volume and price-volume cross-correlation may show varying levels of persistence across structural segments (Patil & Rastogi, 2020). In addition, structural breaks significantly influence various aspects of financial and economic modeling, as corroborated by numerous studies. Recognizing structural breaks in asymmetric GJR-GARCH models reduces volatility persistence in stock and oil returns. Notably, good news has a diminished impact on current volatility when sudden changes are considered (Kartsonakis-Mademlis & Dritsakis, 2020). In cryptocurrency markets, neglecting structural breaks results in an underestimation of volatility persistence, underscoring the importance of integrating these breaks into volatility modeling (Jiang et al., 2023). Incorporating structural breaks in volatility modeling reduces persistence and increases asymmetric volatility for major cryptocurrencies, impacting hedging strategies, derivatives valuations, and risk exposure measurement (Aharon et al., 2023). Structural breaks also affect financial asset connectedness. For example, bond linkage increases when trend breaks occur, and there is growing co-movement between the technology sector and major financial assets under uncertainty (Arnell et al., 2023).

Accounting for structural breaks is paramount for accurate modeling and forecasting in various financial and economic contexts. These breaks can markedly influence volatility persistence, transmission effects, and other critical parameters. Thus, properly accounting for structural breaks can enhance the accuracy of forecasting models, improve risk management strategies, and inform economic policy decisions.

Only a few studies have been discovered on the long-run relationship between the stock market and stock price. For example, in Spain, economic policy uncertainty and stock market volatility negatively impact share prices in both the short and long term, while in Brazil, global stock market uncertainty affects share prices in both time horizons (Gabarre, 2020). The U.S. stock market shows a quantile-varying cointegration relationship with macroeconomic factors, with industrial production having the largest long-run influence on

equity prices (Shahzad et al., 2020). Similarly, a study on the Brazilian stock market showed that global uncertainty affects share prices in both short and long-term horizons. However, in developed markets like Spain, economic policy uncertainty and stock market volatility negatively impact share prices in both the short and long terms (Gabarre, 2020). In emerging markets, research on the Pakistan Stock Exchange found a long-term positive relationship between oil prices, stock returns, and market volatility (Sarfraz et al., 2021).

DATA AND METHODOLOGY

This study employs the Gregory-Hansen Cointegration Test, a residual-based cointegration test that allows for determining a structural break in the cointegration vector (Fountas & Wu, 1996). This technique is an extension of the conventional Engle- Granger cointegration test. It tests for cointegration in regime shifts or structural changes in the long-run relationship between variables (Kasman et al., 2009). This test has been applied in various economic and financial contexts. Its applications span various fields, including fiscal policy, international trade, financial markets, energy economics, and environmental economics, providing more nuanced insights into economic relationships that conventional cointegration tests may overlook. In addition, this research utilizes Error Correction Models (ECM) to estimate the relationship between variables under investigation. This technique often analyzes long-term and short-term relationships between variables, particularly in time series data. These models are applied in various fields to study the dynamics of economic, financial, and environmental phenomena, e.g., economics, finance (Jiang et al., 2023). The Error Correction Models (ECM) for this research can be written as follows:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta X_{t-1} + \gamma(Y_{t-1} - \theta X_{t-1}) + \text{ò}_t, \qquad (1)$$

where Y_t is NASDAQ. X_{t-1} represents the lagged differences of MSFT, NVDA, and AVGO. Δ represents first differences or short-term changes. β_i is the coefficients for the short-term dynamics. γ is the error correction coefficient, showing how quickly the system adjusts to long-run equilibrium. θ represents the long-run relationship between Y_t and X_t. ò_t is the error term.

This research utilizes daily data from Yahoo Finance spanning from July 29, 2019, to July 26, 2024, which includes the NASDAQ Composite (NASDAQ), Microsoft Corporation (MSFT), NVIDIA Corporation (NVDA), and Broadcom Inc. (AVGO).

RESULTS AND DISCUSSION

This section presents the cointegration analysis between NASDAQ and selected technology stocks, emphasizing the role of structural breaks. We outline the descriptive statistics, conduct structural break tests, and apply the Gregory-Hansen Cointegration Test and Error Correction Models to assess long-term market dynamics.

Table 1 – Descriptive statistic

Variable	Obs	Mean	Std. dev.	Min	Max
NASDAQ	1,258	139.3225	42.09103	48.335	234.82
AVGO	1,258	60.80726	33.08956	16.787	182.887
MSFT	1,258	270.0879	79.91005	132.21	467.56
NVDA	1,258	27.73313	26.88684	3.71925	135.58

Table 1 shows that NASDAQ has a mean of 139.32 with a standard deviation of 42.09, ranging from a minimum of 48.34 to a maximum of 234.82. AVGO's average value is 60.81, with a standard deviation of 33.09, fluctuating between 16.79 and 182.89. MSFT shows a mean of 270.09 and a standard deviation of 79.91, ranging from 132.21 to 467.56. NVDA's mean is 27.73, with a standard deviation of 26.89, from 3.72 to 135.58. Figure 1 shows the time series of investigated variables.

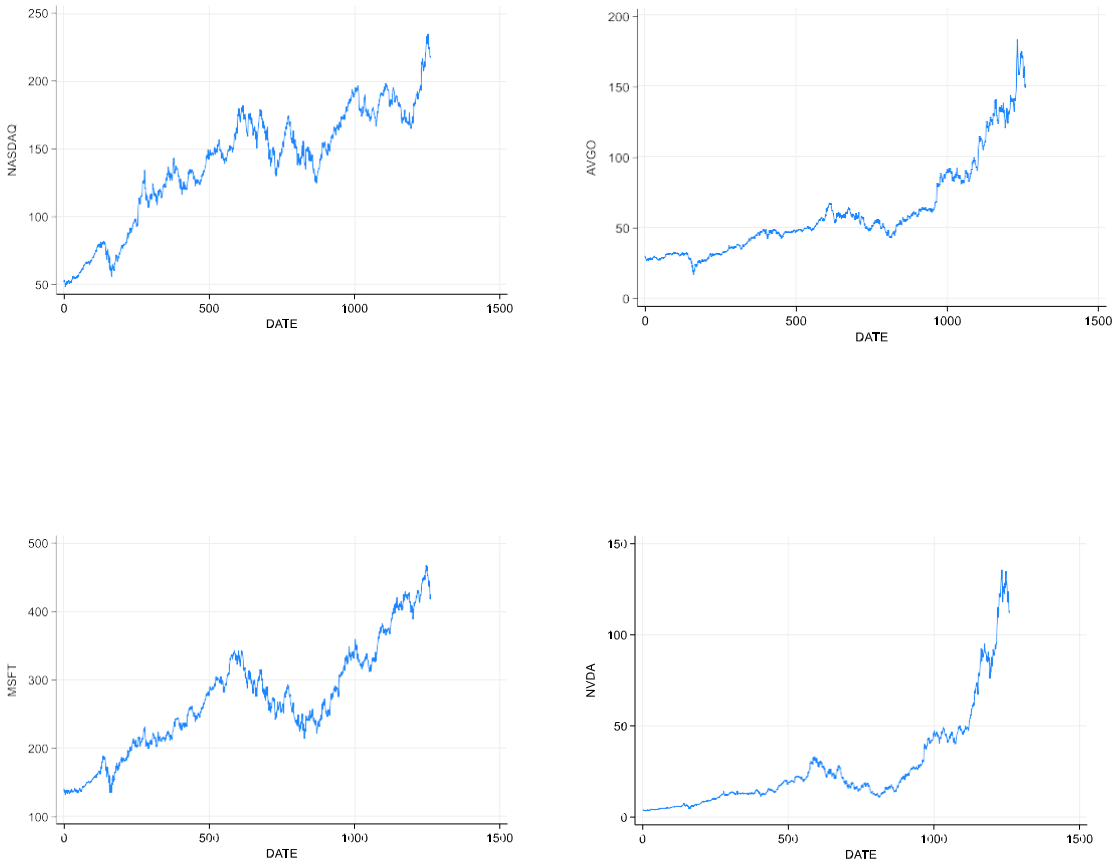


Figure 1 – Time series of investigated variables

Table 2 – Test for a structural break

Type	Test statistic	Critical value (1 percent)	Critical value (5 percent)	Critical value (10 percent)
Recursive	3.1547	1.143	0.9479	0.8499

Table 2 displays the results of the structural break test using the recursive method. The test statistic is 3.1547, which exceeds the critical values at the 1 percent, 5 percent, and 10 percent significance levels (1.1430, 0.9479, and 0.8499, respectively). This indicates strong evidence of a structural break in the dataset, suggesting a significant change in the relationship between the variables over the observed period.

Table 3 – Gregory-Hansen Test for cointegration with regime shifts: change in level

Test	Statistic	Breakpoint	Date	Critical value (1 percent)	Critical value (5 percent)	Critical value (10 percent)
ADF	-4.2	1066	1066	-5.77	-5.28	-5.02
Zt	-4.1	1066	1066	-5.77	-5.28	-5.02
Za	-35.87	1066	1066	-63.64	-53.58	-48.65

Table 4 – Gregory-Hansen Test for cointegration with regime shifts: change in level and trend

Test	Statistic	Breakpoint	Date	Critical value (1 percent)	Critical value (5 percent)	Critical value (10 percent)
ADF	-3.67	256	256	-6.05	-5.57	-5.33
Zt	-3.75	248	248	-6.05	-5.57	-5.33
Za	-29.45	248	248	-70.27	-59.76	-54.94

Table 5 – Gregory-Hansen Test for cointegration with regime shifts: change in regime

Test	Statistic	Breakpoint	Date	Critical value (1 percent)	Critical value (5 percent)	Critical value (10 percent)
ADF	-4.6	1004	1004	-6.51	-6	-5.75
Zt	-4.23	1005	1005	-6.51	-6	-5.75
Za	-38.16	1005	1005	-80.15	-68.94	-63.42

Tables 3, 4, and 5 provide the results of the Gregory-Hansen cointegration tests, assessing structural breaks in different models. In Table 3, the ADF, Zt, and Za statistics are below the 1 percent, 5 percent, and 10 percent critical values, indicating no significant cointegration when considering only level shifts. Similarly, Table 4, which includes both level and trend shifts, shows that the ADF and Zt statistics are again lower than the critical values, indicating a lack of cointegration. However, in Table 5, which considers regime shifts, the ADF and Zt statistics approach the 1 percent, 5 percent, and 10 percent critical values, suggesting a stronger possibility of cointegration with regime changes. Given the findings, the regime shift model appears to be the most appropriate, as it shows a higher likelihood of cointegration than the other models. This suggests that the relationship between NASDAQ and the selected technology stocks is more sensitive to regime changes. Figure 2 shows the breakpoint.

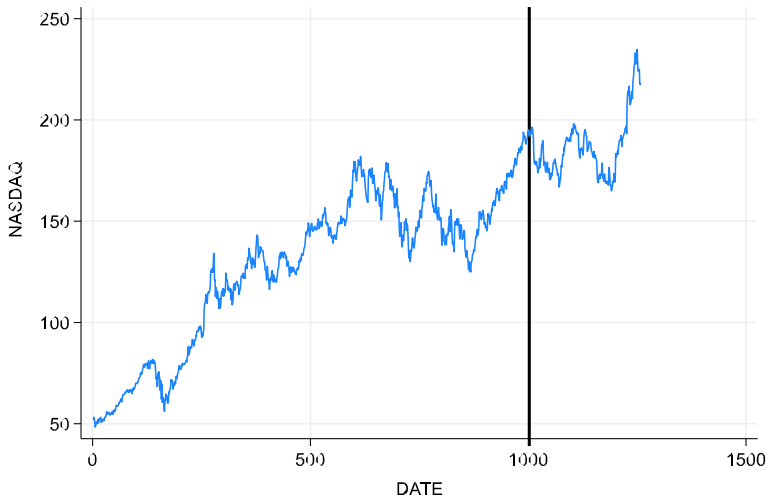


Figure 2 – Breakpoint

Table 6 – The error correction model with structure break

Variable	Coefficient	Std. err.	t	P>|t|	95 percent conf. interval lower	95 percent conf. interval upper
NASDAQ L1.	-0.00991	0.005228	-1.9	0.058	-0.02017	0.000345
AVGO	7.768169	5.909094	1.31	0.189	-3.82473	19.36107
MSFT	-2.92767	2.773443	-1.06	0.29	-8.38183	2.526494
NVDA	45.26001	33.95219	1.33	0.183	-21.4944	111.9844
z	29.5787	27.7934	1.06	0.291	-25.6484	84.80578
z_AVGO1	-10.3342	7.11963	-1.45	0.147	-24.302	3.633634
z_MSFT1	-3.51286	2.86333	-1.23	0.22	-8.1464	1.120679
z_NVDA1	-42.6292	32.8234	-1.3	0.194	-107.025	21.76624
AVGO D1.	0.24776	0.041896	5.91	0	0.165566	0.329955
MSFT D1.	0.339586	0.013396	25.35	0	0.313305	0.365868
LD.	0.024127	0.011246	2.15	0.032	0.002627	0.045626
NVDA D1.	-0.11518	0.055904	-2.06	0.04	-0.22486	-0.0055
_cons	0.436318	1.822695	0.24	0.811	-3.13958	4.012217

Table 7 – The error correction model without structure break

	D.NASDAQ	Coefficient	Std. err.	t	P>t	95 percent conf. interval lower	95 percent conf. interval upper
ADJ							
	NASDAQ L1.	-0.006	0.004	-1.560	0.119	-0.014	0.002
LR							
	AVGO	-4.139	3.295	-1.260	0.209	-10.604	2.325
	MSFT	0.896	0.325	2.750	0.006	0.258	1.534
	NVDA	3.959	3.547	1.120	0.265	-3.000	10.918
SR							
	AVGO D1.	0.250	0.042	5.970	0.000	0.168	0.332

D.NASDAQ	Coefficient	Std. err.	t	P>t	95 percent conf. interval lower	95 percent conf. interval upper
MSFT						
D1.	0.340	0.013	25.490	0.000	0.314	0.366
LD.	0.024	0.011	2.120	0.034	0.002	0.046
NVDA						
D1.	-0.114	0.056	-2.040	0.041	-0.224	-0.005
_cons	0.281	0.309	0.910	0.363	-0.325	0.886

Table 6 presents the Error Correction Model (ECM) with structural breaks, showing that NASDAQ L1 has a marginally significant coefficient of -0.00991 (p=0.058), indicating a slow adjustment to the long-term equilibrium. The short-term coefficients for AVGO and MSFT are significant, with MSFT showing a particularly strong effect (t=25.35, p<0.001). NVDA, while showing some short-term influence, has a weaker impact. This model highlights the significance of short-term dynamics, especially for MSFT, and suggests the presence of structural breaks affecting the long-term relationship. In contrast, Table 7 shows the ECM without structural breaks, where the NASDAQ L1 coefficient is -0.006 (p=0.119), indicating an even slower and non-significant adjustment to the long-term equilibrium. The short-term effects for AVGO, MSFT, and NVDA are significant, with MSFT again having the strongest short-term influence (t=25.49, p<0.001). However, the model shows a weaker long-term relationship without accounting for structural breaks compared to Table 6. Figure 3 shows the recursive cusum plot of NASDAQ in the structural break model.

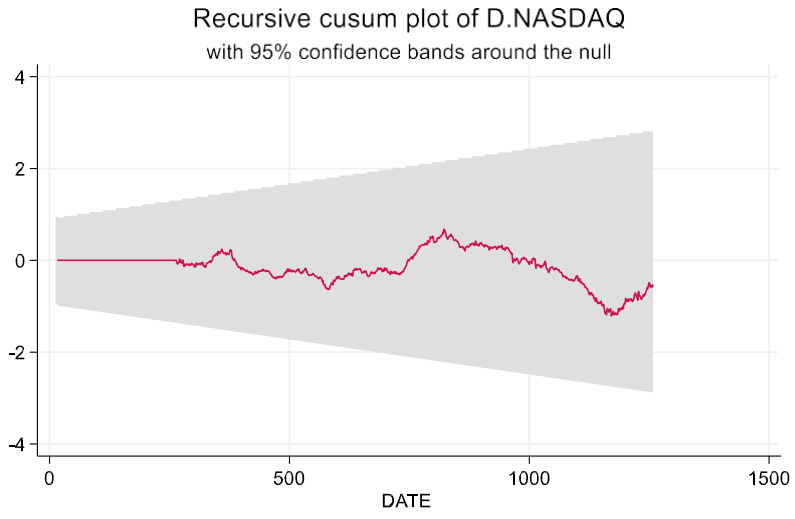


Figure 3 – Recursive cusum plot of NASDAQ in structural break model

Previous studies highlight that structural breaks represent significant changes in time series data, affecting various aspects of financial markets such as volatility, mean, or trend (Cappelli et al., 2020; Check & Piger, 2021). The results of this study confirm this statement. Specifically, the Gregory-Hansen cointegration test reveals that the relationship between NASDAQ and technology stocks is sensitive to changes in market regimes. The significance of structural breaks is further reinforced by the findings of the structural break test, which

indicates strong evidence of a break in the dataset. This aligns with studies demonstrating that structural breaks significantly influence financial and economic modeling (Kartsonakis-Mademlis & Dritsakis, 2020; Jiang et al., 2023). Additionally, the Error Correction Models (ECMs) employed in this study show that when structural breaks are included, NASDAQ adjusts to the long-term equilibrium slowly, with a marginally significant coefficient. This finding aligns with the literature, which argues that neglecting structural breaks can underestimate volatility persistence and lead to inaccurate modeling of financial relationships (Aharon et al., 2023). Conversely, the ECM without structural breaks reveals a slower and non-significant adjustment to long-term equilibrium, indicating that the omission of structural breaks weakens the model's ability to capture the true relationship between the market index and technology stocks.

POLICY IMPLICATION

The analysis reveals that accounting for structural breaks is crucial for understanding the dynamics between stock market indices and technology stock prices. Thus, regulators and policymakers should consider structural breaks when developing financial market regulations and economic policies, as these shifts significantly impact market behavior and the stability of long-term relationships between stock indices and individual stocks. Ignoring these breaks could result in inaccurate risk assessments and misguided policy decisions, leading to increased market vulnerability and misallocation of resources. Additionally, investment policies should be adaptive, recognizing that market regimes change over time and that relationships between stocks and indices are not static. Investment models that incorporate the potential for structural breaks will be more effective in managing risk, especially during significant market disruptions. Investors, portfolio managers, and policy advisors should be aware of the evolving nature of market correlations and avoid relying on models that assume stability in these relationships. For central banks and financial authorities, incorporating structural breaks into stress-testing and market forecasting can improve the anticipation of financial shocks and better inform monetary and fiscal policy responses. This proactive approach enhances market resilience, provides greater financial stability, and aligns investment strategies with the shifting dynamics of market conditions.

CONCLUSION

With financial markets increasingly characterized by volatility and abrupt changes, understanding the effects of these structural shifts on market dynamics is crucial for investors, policymakers, and financial analysts. Previous literature underscores the impact of various factors, such as policy changes and global uncertainty, on stock indices and individual stock prices. However, the long-term relationship between stock market indices and specific technology stocks has not been extensively studied, especially in the context of structural breaks. Therefore, this research investigated the relationship between stock market returns and selected technology stocks, specifically examining the influence of structural breaks on long-term relationships. This study employed the Gregory-Hansen Cointegration Test to detect potential structural breaks and used Error Correction Models (ECM) to analyze both short- and long-term dynamics between variables. The data comprised daily stock prices from July 29, 2019, to July 26, 2024, including the NASDAQ Composite Index and key technology stocks—Broadcom Inc. (AVGO), Microsoft Corporation (MSFT), and NVIDIA Corporation (NVDA). The Gregory-Hansen test was chosen because of its ability to

identify cointegration while accounting for potential regime shifts in the relationship between stock prices and indices, enhancing the robustness of the analysis. The ECMs provided a framework to examine the speed of adjustment to equilibrium in the presence ofstructural breaks, thereby offering insights into both immediate and long-term dynamics in the stock market. The results demonstrated that structural breaks significantly affect the cointegration between NASDAQ and the selected technology stocks. When accounting for regime changes, the results suggested a stronger possibility of cointegration, indicating that the stock market and technology stocks are sensitive to such shifts. Furthermore, the ECM with structural breaks showed that NASDAQ adjusts slowly to long-term equilibrium. In contrast, the adjustment to equilibrium is weaker without accounting for structural breaks. This research suggests that regulators and policymakers must acknowledge the role of structural breaks when developing market regulations and economic policies. The results imply that neglecting these changes can lead to inaccurate risk assessments and suboptimal policy decisions. Investment strategies should also be adaptable to changing market conditions. For central banks and financial authorities, incorporating structural breaks into forecasting and stress-testing enhances the accuracy of predicting market shocks, contributing to greater financial stability.

Future studies

Future research should further explore the impact of structural breaks on the relationship between stock market indices and other sectors beyond technology to provide a more comprehensive understanding of market dynamics across diverse industries. Given the findings on regime shifts, future studies should also investigate the timing and causes of structural breaks, including macroeconomic events, policy changes, or technological advancements, to enhance forecasting models.

REFERENCES

Aharon, D. Y., Butt, H. A., Jaffri, A., & Nichols, B. (2023). Asymmetric volatility in the cryptocurrency market: New evidence from models with structural breaks. *International Review of Financial Analysis*, 87, 102651. https://doi.org/10.1016/j.irfa.2023.102651

Arnell, L., Engström, E., Uddin, G. S., Hasan, M. B., & Kang, S. H. (2023). Volatility spillovers, structural breaks and uncertainty in technology sector markets. *Financial Innovation*, 9(1). https://doi.org/10.1186/s40854-023-00502-5

Aumeboonsuke, V. (2020). Commodity price and the stock market in Thailand. *International Journal of Energy Economics and Policy*, 11(1), 34–40. https://doi.org/10.32479/ijeep.10298

Ballinari, D., & Behrendt, S. (2020). Structural breaks in online investor sentiment: A note on the nonstationarity of financial chatter. *Finance Research Letters*, 35, 101479. https://doi.org/10.1016/j.frl.2020.101479

Caporin, M., & Malik, F. (2019). Do structural breaks in volatility cause spurious volatility transmission?. *Journal of Empirical Finance*, 55, 60–82. https://doi.org/10.1016/j.jempfin.2019.11.002

Cappelli, C., Cerqueti, R., D'Urso, P., & Di Iorio, F. (2020). Multiple breaks detection in financial interval-valued time series. *Expert Systems with Applications*, 164, 113775. https://doi.org/10.1016/j.eswa.2020.113775

Chang, C.-L., & Fang, M. (2022). The connectedness between natural resource commodities and stock market indices: Evidence from the Chinese economy. *Resources Policy*, 78, 102841. https://doi.org/10.1016/j.resourpol.2022.102841

Check, A., & PIGER, J. (2021). Structural Breaks in U.S. Macroeconomic Time Series: A Bayesian Model Averaging Approach. Journal of Money, *Credit and Banking*, 53(8), 1999–2036. https://doi.org/10.1111/jmcb.12822

Chen, W., Cai, X., & Chen, B. (2023). Forecasting China's stock market risk under the background of the Stock Connect programs. *Soft Computing*, 28(3), 2483–2499. https://doi.org/10.1007/s00500-023-08496-z

Fountas, S., & Wu, J.-L. (1996). Are the Greek budget deficits too large? *Applied Economics Letters*, 3(7), 487–490. https://doi.org/10.1080/758540812

Jiang, Z., Mensi, W., & Yoon, S.-M. (2023). Risks in major cryptocurrency markets: Modeling the dual long memory property and structural breaks. *Sustainability*, 15(3), 2193. https://doi.org/10.3390/su15032193

Just, M., & Echaust, K. (2020). Stock market returns, volatility, correlation and liquidity during the COVID-19 crisis: Evidence from the Markov switching approach. *Finance Research Letters*, 37, 101775. https://doi.org/10.1016/j.frl.2020.101775

Kartsonakis-Mademlis, D., & Dritsakis, N. (2020). Asymmetric volatility transmission in Japanese stock market in the presence of structural breaks. *The Japanese Economic Review*, 73(4), 647–677. https://doi.org/10.1007/s42973-020-00051-x

Kasman, A., Vardar, G., Aksoy, G., & Okan, B. (2009). The Turkish stock market integration with developed and emerging countries' stock markets: Evidence from cointegration tests with and without regime shifts. *Review of Middle East Economics and Finance*, 5(1). https://doi.org/10.2202/1475-3693.1120

Ma, C., & Tu, Y. (2022). Group fused Lasso for large factor models with multiple structural breaks. *Journal of Econometrics*, 233(1), 132–154. https://doi.org/10.1016/j.jeconom.2022.02.003

Mai, Z., Kamran, M., & Nawaz Saleem, H. M. (2023). The relationship between political instability and stock market performance: An analysis of the MSCI index in the case of Pakistan. *PLOS ONE*, 18(10), e0292284. https://doi.org/10.1371/journal.pone.0292284

Mohnot, R., Banerjee, A., Ballaj, H., & Sarker, T. (2023). Re-examining asymmetric dynamics in the relationship between macroeconomic variables and stock market indices: empirical evidence from Malaysia. *The Journal of Risk Finance*, 25(1), 19–34. https://doi.org/10.1108/jrf-09-2023-0216

Osabuohien-Irabor, O. (2020). Unit root tests in the presence of structural breaks: Evidence from African stock markets. *Economic Journal of Emerging Markets*, 12(2), 119–137. https://doi.org/10.20885/ejem.vol12.iss2.art1

Patil, A. C., & Rastogi, S. (2020). Multifractal analysis of market efficiency across structural breaks: Implications for the adaptive market hypothesis. *Journal of Risk and Financial Management*, 13(10), 248. https://doi.org/10.3390/jrfm13100248

Sánchez Gabarre, M. E. (2020). Stock prices, uncertainty and risks: Evidence from developing and advanced economies. *European Journal of Government and Economics*, 9(3), 265–279. https://doi.org/10.17979/ejge.2020.9.3.6999

Sarfraz, S., Husnain, M., & Ahmad, M. (2021). Long run and short run co-movement among oil prices and stock market liquidity: Evidence from the emerging equity market of Pakistan. *Sustainable Business and Society in Emerging Economies*, 3(3), 231–241. https://doi.org/10.26710/sbsee.v3i3.1913

Shahzad, S. J. H., Hurley, D., & Ferrer, R. (2020). U.S. stock prices and macroeconomic fundamentals: Fresh evidence using the quantile ARDL approach. *International Journal of Finance & Economics*, 26(3), 3569–3587. https://doi.org/10.1002/ijfe.1976

Solares, E., De-León-Gómez, V., Salas, F. G., & Díaz, R. (2022). A comprehensive decision support system for stock investment decisions. *Expert Systems with Applications*, 210, 118485. https://doi.org/10.1016/j.eswa.2022.118485

Vrînceanu, G., Belaşcu, L., Horobeț, A., & Popescu, C. (2020). The lnfluence of oil price on renewable energy stock prices: An analysis for entrepreneurs. *Studia Universitatis „Vasile Goldis" Arad – Economics Series*, 30(2), 24–35. https://doi.org/10.2478/sues-2020-0010

Xie, W.-J., Yong, Y., Wei, N., Yue, P., & Zhou, W.-X. (2021). Identifying states of global financial market based on information flow network motifs. *The North American Journal of Economics and Finance*, 58, 101459. https://doi.org/10.1016/j.najef.2021.101459

Yılmaz, H. A., & Güzel, F. (2021). How do the exchange rates affect the sector indices? A dynamic panel data analysis for Borsa Istanbul. *Istanbul Journal of Economics / İstanbul İktisat Dergisi*, 71(2), 411–434. https://doi.org/10.26650/istjecon2021-970320

Zeng, Q., Lu, X., Dong, D., & Li, P. (2022). Category-specific EPU indices, macroeconomic variables and stock market return predictability. *International Review of Financial Analysis*, 84, 102353. https://doi.org/10.1016/j.irfa.2022.102353

FORECASTING STOCK MARKET: AN APPLICATION OF ARIMA AND BROWNIAN MOTION MODELS

Voranon Khundilokkamol[A], Suvimon Chaiphanphong[B], Adirek Vajrapatkul[C]

ABSTRACT

The importance of stock market forecasting lies in its ability to provide critical insights for investors, businesses, and policymakers, facilitating informed decision-making and enhancing investment strategies. Accurate predictions of market trends can optimize trading strategies, improve risk management, and support economic stability. This research aims to contribute to the field of financial forecasting by comparing the effectiveness of two prominent models, namely, the Autoregressive Integrated Moving Average (ARIMA) model and 3 Brownian motion models, including the Vasicek, Brennan- Schwartz, and Cox-Ingersoll-Ross (CIR) models. The study utilizes daily data from the SET index, covering the period from July 30, 2019, to July 26, 2024, sourced from Yahoo Finance. The findings of this research indicate that the Brownian Motion model outperforms the ARIMA model in predicting the SET index and is thus appropriate for forecasting applications. The selected model shows the increasing trend in the SET index, which can be used to provide information for effective financial decision-making.

Keywords: *Stock Market Forecasting, ARIMA Model, Brownian Motion model, SET Index*

INTRODUCTION

Stock markets are platforms where publicly traded company shares are bought and sold. Integral to the financial ecosystem, they facilitate capital allocation, price discovery, and investment opportunities. More than just trading venues, stock markets significantly impact economic growth, corporate governance, and financial development. They serve as vital indicators of economic health and are pivotal in resource allocation. Stock markets enable companies to raise capital by issuing shares, which can be used for expansion, research and development, or other strategic initiatives. Research shows that in market- based financial systems, R&D expenditures are highly valued by the stock market (Booth et al., 2005). Additionally, stock markets allow investors to participate in corporate growth and wealth creation. The evolution of stock markets has led to three distinct business models: global exchanges, regional exchanges, and diversified exchanges. This transformation reflects the increasing complexity and interconnectedness of global financial markets (Galper, 2001). Moreover, stock market liberalization can lead to more rational pricing behavior and improved market efficiency, highlighting their dynamic nature and potential for development (Song et al., 2003).

[A] *Academician, Teaching, Faculty of Management Science, Pacific Institute of Management Science, Thailand. E-mail:Jued@live.com Orcid: https://orcid.org/0000-0002-0627-8439*

[B] *PhD in Business administration, Faculty of Management Science, Pacific Institute of Management Science, Thailand. E-mail: Suvimom.c@hotmail.com Orcid: https://orcid.org/0000-0002-0627-8439*

[C] *PhD in Economics, School of Economics, Sukhothai Thammathirat Open University, Thailand. E-mail: a.vajrapatkul@gmail.com Orcid: https://orcid.org/0000-0002-0627-8439*

Stock markets are fundamental to modern economies, serving as barometers of economic health, facilitators of capital allocation, and drivers of corporate behavior. They influence investment decisions, economic growth, and international capital flows. As financial markets evolve, understanding the role and dynamics of stock markets remains crucial for investors, policymakers, and researchers. Stock markets act as platforms for trading company shares and facilitating capital allocation. They play a significant role in economic growth and development by providing liquidity and channeling funds to productive investments (Chikwira & Mohammed, 2023; Salameh & Ahmad, 2020). The importance of stock markets is evident in their positive correlation with economic growth. Studies have shown a statistically significant association between stock market development and economic growth, though this relationship may vary in different contexts (Chikwira & Mohammed, 2023). In addition, stock markets are characterized by randomness and dynamic correlation patterns, making them challenging to predict (Dong et al., 2024; Kulkarni et al., 2024). Accurate predictions and analysis of stock market trends are vital for investors to make informed decisions, potentially impacting economic operations positively (Dong et al., 2024). However, understanding stock market dynamics is crucial for investors, regulators, and policymakers to make informed decisions, manage risks, and ensure market efficiency (Alsanousi et al., 2024; Dong et al., 2024; Kulkarni et al., 2024).

Stock market forecasting presents several notable advantages for investors, analysts, and financial institutions. One primary benefit is enhanced decision-making. Another critical benefit is risk reduction, portfolio management and investment strategies (Al-Nefaie & Aldhyani, 2022; Khan et al., 2023; Pagliaro, 2023). Researchers have extensively studied stock market forecasting through various methodologies, broadly categorized into traditional methods and advanced computational techniques. Traditional methods encompass linear and nonlinear models, which have sometimes outperformed artificial intelligence and frequency domain models (Mallikarjuna & Rao, 2019). Nonetheless, the efficacy of these traditional models varies across different markets, and no single model is universally applicable. In recent years, advanced computational techniques, particularly machine learning (Rath et al., 2024) and deep learning algorithms (Fathali et al., 2022). The choice of methodology depends on the specific market, available data, and research objectives. These more advanced techniques which have shown promising results compared to traditional methods such as ARIMA (Mian, 2023). Stock market forecasting remains a critical and challenging task for researchers. The field continues to evolve, focusing on integrating multiple data sources, exploring nonlinear relationships, and leveraging advanced learning techniques to enhance prediction accuracy (Singh & Malhotra, 2024; Xu et al., 2023).

Brownian motion significantly influences stock market forecasting, as evidenced by previous studies, e.g., Geometric Brownian Motion (GBM), which is widely employed to model stock market index evolution (Brătian et al., 2022), and the quantum Brownian motion model, which helps interpret fat-tail phenomena and non-Markovian behaviors in stock indices (Meng et al., 2016). Brownian motion and its variations are integral to stock market forecasting because they can model the stochastic nature of price movements.

In the investigation of variables dynamics, particularly interest rate, the well-known models that incorporate Brownian motion in the model formulation are the Vasicek model, Brennan-Schwartz model, and CIR (Cox-Ingersoll-Ross) model. These models are widely used in financial mathematics to describe the behavior of interest rates over time. They are part of the equilibrium models of the term structure of interest rates, which determine the yield curve by modeling the dynamics of short-term interest rates using stochastic processes (Vasicek, 2007; Yun & Gao, 2020). Therefore, their ability to capture the stochastic processes that may exist in the stock market motivates this research to apply these models in

investigating stock market movement.

Due to the increasing complexity and volatility in financial markets, particularly in the stock market. Though widely used, traditional models like the ARIMA model often struggle to accurately predict market behavior, especially in volatile and unpredictable environments like the Stock Exchange of Thailand (SET). This research identifies the need to evaluate alternative models, such as the Brownian motion-based models, that can capture stock prices' stochastic and non-linear nature. This research contributes to this domain by offering a comparative analysis of ARIMA and Brownian motion-based models in Thailand's stock market environment. The remaining sections of this research are organized as follows. The second section will explore pertinent concepts related to this research. Section 3 will outline the research methodology employed in this study. Subsequently, the results of the analysis and discussions will be presented.

LITERATURE REVIEW

This section aims to explore key concepts and empirical studies relevant to this research, including the Efficient Market Hypothesis (EMH) and Brownian Motion.

Efficient Market Hypothesis (EMH)

The Efficient Market Hypothesis (EMH) posits that financial markets are efficient, with current stock prices fully reflecting all available information about a firm's value (Rossi, 2015). According to EMH, when new information arises, the market quickly adjusts, rendering future values unpredictable (Orquín-Serrano, 2020) or forecasting (Htun et al., 2024), making it impossible to consistently achieve excess profits using that information (Mockus & Raudys, 2010; Rossi, 2015).

Despite its foundational role in financial theory, EMH has faced significant challenges and criticisms. Empirical evidence has documented return predictability and calendar anomalies that contradict the EMH (Rossi, 2015). Consequently, alternative hypotheses have gained traction. The Fractal Market Hypothesis (FMH) suggests that markets are stabilized by aligning the demand and supply of investors' investment horizons, rather than assuming market equilibrium as EMH does (Karp & Vuuren, 2019; Vácha & Vošvrda, 2005). Furthermore, the Adaptive Market Hypothesis (AMH) proposes that market efficiency varies over time, evolving with changing market conditions (Khuntia & Pattanayak, 2017).

While the EMH has been a cornerstone in finance, its validity as a comprehensive model for financial markets is increasingly questioned. Alternative hypotheses and empirical studies indicate that market behavior is more intricate than EMH suggests, with factors such as investor behavior, time-varying efficiency, and fractal structures influencing market dynamics (Karp & Vuuren, 2019; Khuntia & Pattanayak, 2017; Rossi, 2015; Vácha & Vošvrda, 2005).

Ongoing research continues to test the validity of the EMH and explore alternative explanations for market behavior. Some studies support the EMH (Araujo & Fernandes, 2021), while others challenge its premises (Kilic et al., 2023). The debate on market efficiency underscores the complex nature of financial markets and the necessity for continued research to fully understand their dynamics.

In stock price forecasting, the weak form of the Efficient Market Hypothesis (EMH) posits that current market prices fully incorporate all available information from past prices, rendering the prediction of future prices based solely on historical data challenging

(Shmilovici & Ben-Gal, 2012; Shmilovici et al., 2003). This suggests that consistent prediction of stock prices is problematic due to the absence of recurring patterns (Shmilovici & Ben-Gal, 2012). However, several studies challenge this notion by demonstrating potential predictability in stock prices.

Contrary to the EMH, research using universal prediction algorithms and data compression techniques has identified recurring patterns in stock price data, suggesting market inefficiencies that could be exploited for excess returns (Shmilovici & Ben-Gal, 2012; Shmilovici et al., 2003). Additionally, studies on the Chinese stock market reveal high predictability for a majority of stocks, with over 73 percent achieving prediction accuracy greater than 70 percent (Chen et al., 2023). While the EMH implies stock prices should be unpredictable, empirical evidence presents a more nuanced picture. For example, the US Socially Responsible Index (SRI) and Shariah Compliance Index (SCI) have been found to violate the weak form of EMH, allowing for short-term price predictions using historical data (Khan et al., 2021). However, the degree of predictability varies across different markets and time periods, with some studies supporting the EMH for certain stock exchanges (Munir et al., 2012; Shmilovici & Ben-Gal, 2012).

These findings underscore the complexity of financial markets and the ongoing debate regarding the validity of the EMH in stock price forecasting. In contradiction to the EMH, some studies have demonstrated that the weak form of EMH is not valid in certain markets, such as the US SRI and SCI, where historical data can predict short-term future price movements using technical models like ARIMA (Khan et al., 2021). Moreover, the complexity of financial markets challenges the EMH, as autonomous price patterns can emerge independently of informational efficiency (Maloumian, 2022).

The EMH suggests that stock prices follow a random walk, implying that future price movements are independent of past trends. However, recent studies challenge this notion by demonstrating the potential of machine learning techniques to predict stock price movements with some degree of accuracy (Htun et al., 2024; Zhang & Lu, 2024). While the EMH posits market efficiency, research has shown that factors such as managerial optimism can influence stock price returns over subsequent periods (Wang et al., 2024). This contradiction highlights the complex interplay between market efficiency and behavioral factors in stock price dynamics.

Furthermore, incorporating stock correlations and market interdependencies into prediction models can enhance forecasting accuracy, suggesting that markets may not be entirely efficient (Zhang & Lu, 2024). While the EMH remains a fundamental theory in finance, emerging research indicates that stock price forecasting may be possible to some extent. The integration of advanced machine learning techniques, consideration of behavioral factors, and analysis of market correlations have shown promise in improving prediction accuracy, challenging the strict interpretation of market efficiency (Htun et al., 2024; Wang et al., 2024; Zhang & Lu, 2024). These findings suggest that while markets may be largely efficient, there may be opportunities for skilled analysts and sophisticated algorithms to identify patterns and make informed predictions.

Brownian Motion

Brownian motion is a fundamental phenomenon observed across diverse scientific disciplines, including physics, biology, chemistry, and finance (Maragó et al., 2010; Metzler, 2019). It describes the random movement of particles suspended in a fluid, driven by collisions with fast-moving molecules in the medium. Albert Einstein's 1905 theoretical explanation of Brownian motion has become a cornerstone in non-equilibrium statistical mechanics (Sharma

& Vishwamittar, 2005). Brownian motion is a complex phenomenon with wide-ranging applications. Its study has led to the development of various theoretical frameworks, including fractional Brownian motion (Chow, 2011), active Brownian motion (Glück et al., 2009), and G-Brownian motion (Lin & Zhang, 2017). Characterized by random changes over time, Brownian motion is observed in systems such as fluid environments, stock behavior, and renewable energy generation (Echenausía-Monroy et al., 2022). It is a fundamental concept in physics and mathematics, describing the erratic movement of particles in a fluid. Several variations and extensions of Brownian motion have been developed to model more complex phenomena, e.g., Fractional Brownian motion (FBM) (Balcerek & Burnecki, 2020; Savitskii, 2019), Multifractional Brownian motion (MFBM) (Balcerek & Burnecki, 2020), and generalized fractional Brownian motion (Ichiba et al., 2021), each addressing specific aspects of complex systems and phenomena.

Forecasting under Brownian motion presents unique challenges due to its inherent stochastic nature. Nevertheless, several advanced methodologies have been developed to tackle these challenges effectively. Geometric Brownian Motion (GBM) has been extensively employed to model stock market behavior and forecast index values. Numerous studies have assessed its effectiveness and proposed modifications to enhance its accuracy. For instance, GBM has demonstrated suitability in forecasting stock market index values, accurately describing their future evolution. However, a modified version, mGBM, which accounts for two states of economic conditions (non-crisis and financial crisis), offers a more precise depiction of stock index evolution. This was evidenced through analyses of the DAX, S&P 500, and SHANGHAI Composite indexes (Brătian et al., 2022). While GBM remains foundational in stock market forecasting, recent research suggests that modifications or alternative models may provide more accurate predictions under certain market conditions (Hu et al., 2022). These include incorporating economic states (Brătian et al., 2022), utilizing fractional Brownian motion (Garcin, 2021; Liu & Huang, 2020; Savitskii, 2019), and combining it with other models such as GARCH (Liu & Huang, 2020). The choice of model depends on specific market characteristics and the forecasting horizon (Brătian et al., 2021). These findings underscore the ongoing evolution of stock market forecasting techniques and the necessity for models that can capture complex market behaviors.

DATA AND METHODOLOGY

Autoregressive Integrated Moving Average (ARIMA) is a widely used statistical model for time series forecasting and analysis. It combines autoregression, differencing, and moving average components to model and predict future values based on past observations (Holakouie-Naieni et al., 2024; Ramadan et al., 2024). This model has been widely applied across various fields for time series forecasting and analysis, e.g., air quality prediction (Ramadan et al., 2024), drought prediction (Soekirno et al., 2024). public health prediction (Holakouie-Naieni et al., 2024), and finance prediction (Olorunnimbe & Viktor, 2024).

In this research, the ARIMA model (Fattah et al., 2018) can be written as follows:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p} + \theta_1 \text{ò}_{t-1} + \theta_2 \text{ò}_{t-2} + \cdots + \theta_q \text{ò}_{t-q} + \text{ò}_t, \quad (1)$$

where Y_t denotes the stock market index. $\phi_1, \phi_2, \ldots, \phi_p$ are the parameters of the autoregressive model. $\theta_1, \theta_2, \ldots, \theta_q$ are the moving average coefficients. ò$_t$ is the white noise error term.

The stochastic model (Strickland, 1996; Udoye et.al., 2020) can be derived as follows:

$$dr_t = \lambda(\mu - r_t)dt + \sigma dW_t \,, \tag{2}$$

where r_t is the current interest rate. λ is the speed of reversion to the mean. It determines how quickly the interest rate reverts to the long-term mean. μ The long-term mean level of the interest rate. dW_t A Wiener process or Brownian motion term. It introduces randomness into the model, representing the unpredictable nature of the interest rate movements. The drift term indicates that if the current rate r is below the mean θ, it will tend to increase; if it is above θ, it will tend to decrease. The diffusion term σdW adds a random fluctuation to the interest rate, making the model stochastic.

From (1), using the integrating term, it provides that

$$e^{\lambda t}\, dr_t + e^{\lambda t}\, \lambda r_t dt = e^{\lambda t}\, \lambda\mu + e^{\lambda t}\, \sigma\, dW_t. \tag{3}$$

Then, integrating by the respected time interval,

$$\int_0^T d\,(e^{\lambda t} r_t) = \int_0^T e^{\lambda t}\, \lambda\mu dt + \int_0^T e^{\lambda t}\, \sigma dW_t. \tag{4}$$

This implies that

$$r_T = r_0 e^{-\lambda T} + \mu\left(1 - e^{-\lambda T}\right) + \sigma \int_0^T e^{-\lambda\cdot(T-t)}\, dW_t. \tag{5}$$

The expected value and variance are given by

$$E(r_T) = r_0 e^{-\lambda T} + \mu\left(1 - e^{-\lambda T}\right), \tag{6}$$

$$Var(r_T) = E(r_T - E(r_T))^2) = \sigma^2\, \frac{1-e^{-2\lambda T}}{2\lambda}. \tag{7}$$

Hence, the solution of SDE in Vasicek form is given by:

$$r_{t+\Delta t} = r_t e^{\lambda\Delta t} + \mu\left(l - e^{-\lambda\Delta t}\right) + \sigma\sqrt{\frac{l-e^{-2\cdot\lambda\Delta t}}{2\lambda}}\, dW_t. \tag{8}$$

where r_t is the current market index. λ denotes the speed of mean reversion. θ represents long-term mean interest rate. σ is the volatility of the market index. Z stands for the standard normal random variable.

The Brennan-Schwartz model, which is a variation of the Vasicek model that incorporates a stochastic volatility component, can be expressed as:

$$r_{t+\Delta t} = r_t e^{\lambda\Delta t} + \mu\left(l - e^{-\lambda\Delta t}\right) + \sigma\, r_t\sqrt{\frac{l-e^{-2\cdot\lambda\Delta t}}{2\lambda}}\, dW_t. \tag{9}$$

The Cox-Ingersoll-Ross (CIR) model describes the dynamics of interest rates, ensuring that the interest rate remains positive can be written by:

$$r_{t+\Delta t} = r_t e^{\lambda\Delta t} + \mu\left(l - e^{-\lambda\Delta t}\right) + \sigma\sqrt{r_t}\sqrt{\frac{l-e^{-2\cdot\lambda\Delta t}}{2\lambda}}\, dW_t. \tag{10}$$

This research uses the daily data of the SET index between 7/30/2019 and 7/26/2024, which was downloaded from Yahoo Finance.

RESULTS

This section will focus on evaluating the performance of different models in forecasting the SET index, specifically comparing ARIMA and Brownian motion-based models. This section presents statistical findings, including Root Mean Squared Error (RMSE) values, to identify the most effective model for accurate market predictions. Table 1 shows descriptive statistics.

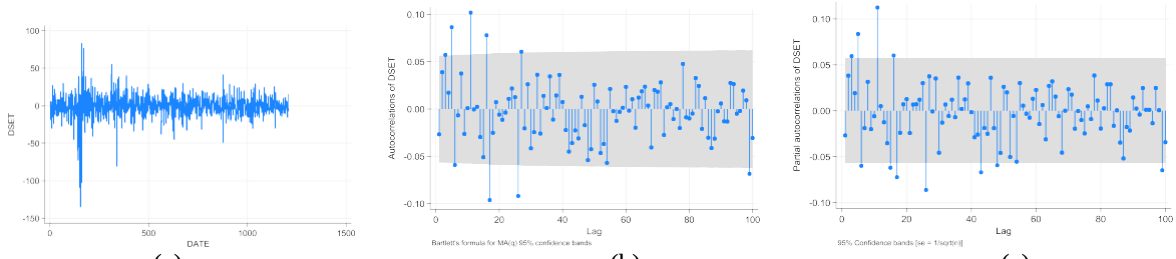
Table 1 – Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
SET	1207	1511.437	137.8454	1024.46	1713.2

Table 2 – Dickey-Fuller test of SET index

Statistic	Level	First difference
Dickey–Fuller test statistic	-1.805	-35.611
P-value	0.378	0.000

As shown in Table 2, the Dickey-Fuller test results present the test statistic at both the level and first-difference stages. At this level, the Dickey-Fuller test statistic is -1.805, with a p-value of 0.378, indicating that the null hypothesis of a unit root cannot be rejected, implying non-stationarity in the data. However, after first differencing, the test statistic drastically improves to -35.611, with a p-value of 0.000. This suggests that the null hypothesis of a unit root is rejected, confirming that the series becomes stationary after first differencing. Figure 1 shows the DSET series and correlogram, which included the Autocorrelation function (ACF) and Partial Autocorrelation Function.



(a) (b) (c)

Figure 1 – (a) DSET series, (b) Autocorrelation function (ACF), (c) Partial Autocorrelation Function

Table 3 – ARIMA model comparison

Model	RMSE
ARIMA(3,1,3)	14.442646
ARIMA(5,1,3)	14.334252
ARIMA(6,1,3)	14.328739
ARIMA(3,1,5)	14.331571
ARIMA(5,1,5)	14.303673
ARIMA(6,1,5)	14.300837

The comparison of the ARIMA model in Table 3 indicates that ARIMA(615) have the highest predictive accuracy.

Table 4 – ARIMA(6,1,5) model summary

Metric	Value
Number of obs	1,206.000
Wald chi2(11)	1,938.040
Log likelihood	-4,919.604
Prob > chi2	0.000

Table 5 – ARIMA (6,1,5) model estimation

Term	Coefficient	Std. Err.	z	P>|z|	95 percent Conf. Interval - Lower	95 percent Conf. Interval - Upper
_cons	- 0.334	0.493	- 0.680	0.497	- 1.300	0.631
ar.L1	- 0.895	0.287	- 3.120	0.002	- 1.456	- 0.333
ar.L2	- 0.400	0.215	- 1.850	0.064	- 0.822	0.023
ar.L3	- 0.092	0.233	- 0.390	0.697	- 0.550	0.367
ar.L4	- 0.491	0.193	- 2.540	0.011	- 0.869	- 0.112
ar.L5	- 0.430	0.181	- 2.380	0.017	- 0.784	- 0.076
ar.L6	0.038	0.043	0.870	0.382	- 0.047	0.122
ma.L1	0.873	0.289	3.020	0.003	0.306	1.440
ma.L2	0.421	0.212	1.980	0.048	0.004	0.837
ma.L3	0.170	0.231	0.730	0.463	- 0.284	0.623
ma.L4	0.581	0.177	3.280	0.001	0.234	0.929
ma.L5	0.559	0.174	3.220	0.001	0.090	1.027
/sigma	14.299	0.148	96.360	-	14.008	14.590

The ARIMA (6,1,5) model summary in Table 4 provides key metrics that indicate the model's performance. The model achieves a high Wald chi-squared value of 1938.04, which is significant at the 0.000 level, demonstrating that the model fits the data well. In Table 5, the model estimation shows that AR (1), AR (4), AR (5), MA (1), MA (2), MA (4), and MA (5) coefficients are significant, as their p-values are below 0.05. These terms contribute to the model's ability to capture the dynamics of the SET index. Figure 2 shows the residual series.

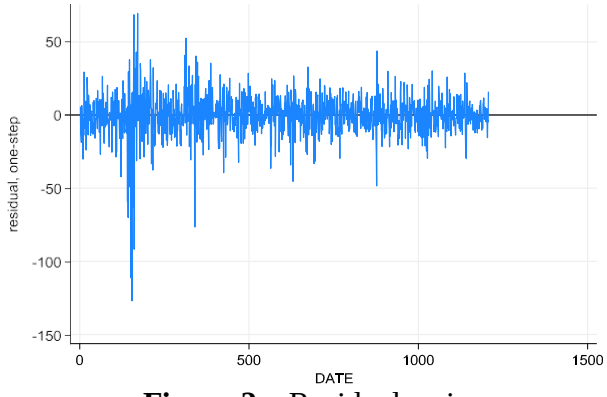


Figure 2 – Residual series

Table 6 – Portmanteau test for white noise

Test	Value
Portmanteau (Q) statistic	44.3755
Prob > chi2(40)	0.2924

Table 7 – Shapiro–Wilk W test for Normality of Residuals

Variable	W	V	z	Prob>z
error	0.90134	73.803	10.733	0.000

Table 8 – Autoregressive Conditional Heteroskedasticity

Term	Coefficient	Std. Err.	z	P>|z|	95 percent Conf. Interval - Lower	95 percent Conf. Interval - Upper
_cons	0.002	0.441	0.010	0.996	- 0.863	0.868
/SIGMA2	204.514	3.428	59.660		197.796	211.23
				0.000		

Table 6 presents the results of the Portmanteau test for white noise, which indicates that the model is independently distributed, suggesting no significant autocorrelation in the residuals. Table 7 shows the results of the Shapiro-Wilk W test for normality of residuals, indicating a significant deviation from normality. Table 8 provides the results of the Autoregressive Conditional Heteroskedasticity (ARCH) test, which assesses whether there is heteroskedasticity in the residuals. The coefficient for the sigma squared term is significant, with a p-value of 0.000 and a value of 204.514, indicating the presence of heteroskedasticity in the residuals. Figure 3 shows the inverse roots of ARMA polynomials. Figure 3 shows Actual and predicted values from (a) the ARIMA model, (b) the Brennan-Schwartz model, (c) the Cox-Ingersoll-Ross (CIR) model, and (d) the Vasicek Model.

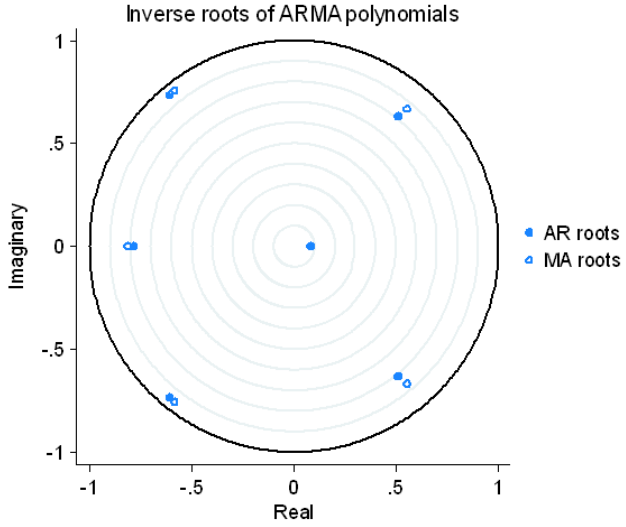


Figure 4 – Inverse roots of ARMA polynomials

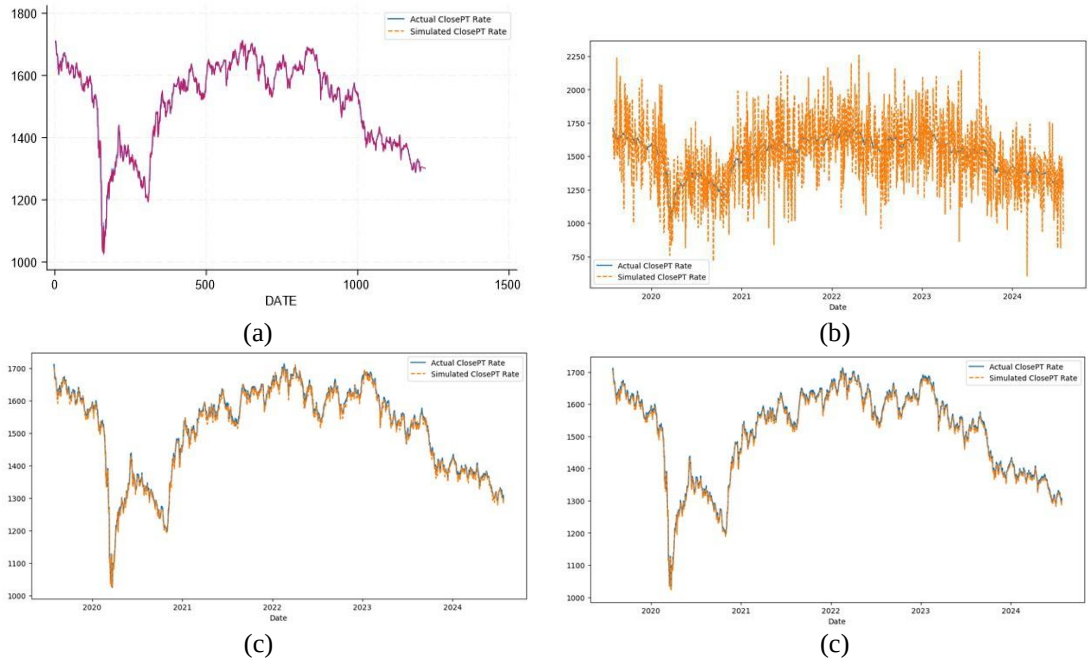


Figure 5 – Actual and predicted values from (a) the ARIMA model, (b) the Brennan-Schwartz model, (c) the Cox-Ingersoll-Ross (CIR) model, and (d) the Vasicek Model

Table 9 – Model comparison

Criteria	ARIMA (6,1,5)	Vasicek model model	Brennan-Schwartz model	Cox-Ingersoll-Ross (CIR) model
RMSE	14.300837	7.5136538	218.4818843	9.390400338

Table 9 compares the performance of the ARIMA (6,1,5) model with the Vasicek, Brennan-Schwartz, and Cox-Ingersoll-Ross (CIR) models using the Root Mean Squared Error (RMSE) as the evaluation criterion. Among the models, the Vasicek model achieves the lowest RMSE at 7.5137, indicating the highest accuracy in forecasting the SET index.

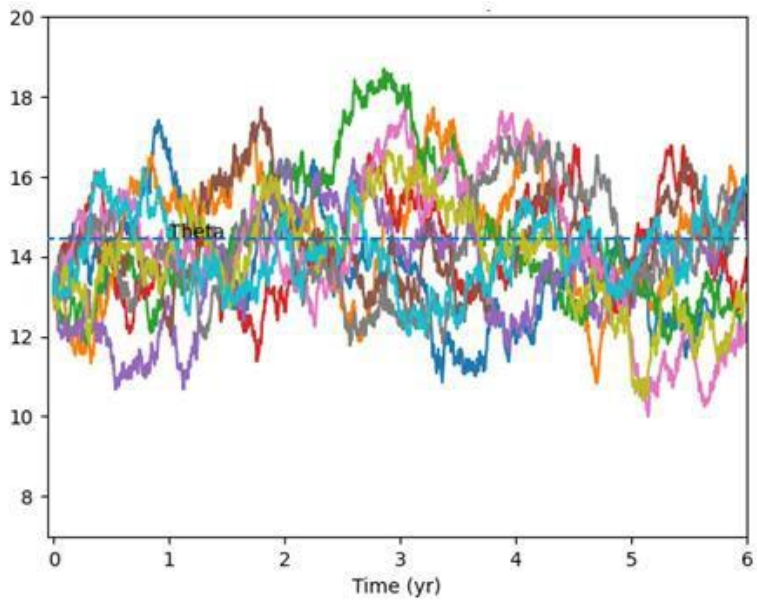


Figure 6 – SET changing rate from the Vasicek Model

Figure 5 presents the simulation results from the Vasicek model, indicating that the SET index may grow by approximately 14.282 percent over the next six years, with the standard error of the sample mean equal to 0.42528 and a 95 percent confidence interval ranging from 13.32010 percent to 15.24421 percent.

DISCUSSION

The findings of this research show that Brownian motion-based models, particularly the Vasicek model, outperform the ARIMA and the rest of the models in forecasting the SET index, indicated by a lowest Root Mean Squared Error (RMSE) of 7.5137, providing a more accurate forecast of market trends. These findings resonate with previous studies in the literature that highlight the limitations of traditional models like ARIMA, especially in complex and volatile markets (Brătian et al., 2022). Brownian motion models, which incorporate stochastic elements, such as randomness in stock price movements, have been shown to better capture the dynamic and unpredictable nature of financial markets. The concepts from the AMH further support these results. while EMH argues that markets are efficient and, therefore, unpredictable, real-world market behavior often displays inefficiencies. This supports AMH, which asserts that market efficiency evolves over time and that there may be periods when forecasting models like Vasicek can offer valuable predictive insights (Khuntia & Pattanayak, 2017). Therefore, the success of the Vasicek model in this research highlights the potential for predictive modeling, even in markets that might otherwise be considered efficient under the EMH. Additionally, the success of Brownian motion-based models is consistent with previous findings, where these models have been employed to simulate stock market behaviors more effectively, particularly under varying economic conditions (Brătian et al., 2021). Geometric Brownian Motion (GBM) models, for instance, have been widely utilized to predict stock indices, and modifications such as the Vasicek model have improved forecast accuracy by accounting for volatility and market fluctuations (Liu & Huang, 2020). The Vasicek model's strong performance in this study reinforces its value in financial forecasting, particularly for its ability to model interest rates and stock index movements through a stochastic framework.

POLICY IMPLICATION

The findings of this research have significant policy implications for financial regulators, investors, and policymakers. The superior performance of the Vasicek model highlights the need to incorporate more sophisticated, stochastic-based models in financial decision-making and policy formulation. Regulators can leverage these models to predict market trends better and detect early signs of volatility, enabling proactive measures to maintain market stability and prevent financial crises. For investors, the accuracy can be used to enhance portfolio management strategies, particularly in volatile markets. Investors can make more informed decisions about asset allocation and risk management by relying on models that account for market randomness and fluctuations, thus optimizing their returns while mitigating risks. Policymakers can also use these findings to develop financial policies that reflect the unpredictable nature of markets. By understanding that markets may not always follow efficient patterns.

FUTURE RESEARCH

Based on the findings of this research, future studies could explore the application of other advanced stochastic models, such as Geometric Brownian Motion (GBM) or models incorporating jump diffusion, to further enhance the accuracy of stock market forecasts. Also, the research may employ machine learning techniques to improve predictive capabilities. Additionally, research could expand beyond the SET index to examine the applicability of these models across various global financial markets, allowing for a more comprehensive understanding of their effectiveness in different economic conditions. Furthermore, investigating the impact of macroeconomic factors on these models' forecasting abilities would provide deeper insights into how external shocks influence market behavior and model performance.

CONCLUSION

Stock market forecasting is crucial for investors, businesses, and policymakers, enhancing decision-making, risk management, and economic planning. The study aimed to identify which model provided more accurate predictions, thereby contributing valuable insights to financial forecasting. This research aims to compare the effectiveness of the Autoregressive Integrated Moving Average (ARIMA) model and Brownian motion-based models, specifically the Vasicek, Brennan-Schwartz, and Cox-Ingersoll-Ross (CIR) models, in forecasting the Stock Exchange of Thailand (SET) index, with the daily data from the SET index, covering the period from July 30, 2019, to July 26, 2024. The data was sourced from Yahoo Finance. In this study, the results revealed that the Vasicek model significantly outperformed other models showed by the lowest RMSE. This suggests that the Vasicek model, which better accounts for volatility and market uncertainty, is more effective in forecasting the SET index. Thus, this study recommends that financial regulators and policymakers benefit from using stochastic models to predict market trends, enabling them to implement proactive measures to ensure market stability. Investors, too, can leverage the enhanced forecasting accuracy to improve portfolio management, reduce risks, and optimize returns.

REFERENCES

Al-Nefaie, A. H., & Aldhyani, T. H. H. (2022). Predicting Close Price in Emerging Saudi Stock Exchange: Time Series Models. Electronics, 11(21), 3443. https://doi.org/10.3390/electronics11213443

Alsanousi, A. T., Baghdadi, M. A., Alqahtani, A. Y., & Makki, A. A. (2024). A Hybrid MCDM Approach Using the BWM and the TOPSIS for a Financial Performance-Based Evaluation of Saudi Stocks. Information, 15(5), 258. https://doi.org/10.3390/info15050258

Balcerek, M., & Burnecki, K. (2020). Testing of Multifractional Brownian Motion. Entropy, 22(12), 1403. https://doi.org/10.3390/e22121403

Brătian, V., Oprean-Stan, C., Dinga, E., Ionescu, G.-M., & Acu, A.-M. (2021). Efficient or Fractal Market Hypothesis? A Stock Indexes Modelling Using Geometric Brownian Motion and Geometric Fractional Brownian Motion. Mathematics, 9(22), 2983. https://doi.org/10.3390/math9222983

Brătian, V., Șerban, R.-A., Acu, A.-M., & Mihaiu, D. M. (2022). Geometric Brownian Motion (GBM) of Stock Indexes and Financial Market Uncertainty in the Context of Non- Crisis and Financial Crisis Scenarios. Mathematics, 10(3), 309. https://doi.org/10.3390/math10030309

Booth, G. G., Junttila, J., Kallunki, J.-P., Rahiala, M., & Sahlström, P. (2005). How does the financial environment affect the stock market valuation of R&D spending? Journal of Financial Intermediation, 15(2), 197–214. https://doi.org/10.1016/j.jfi.2005.03.003

Chen, Y., Xu, X., Lan, T., & Zhang, S. (2023). The Predictability of Stock Price: Empirical Study on Tick Data in Chinese Stock Market. Big Data Research, 35, 100414. https://doi.org/10.1016/j.bdr.2023.100414

Chow, W. C. (2011). Fractal (fractional) Brownian motion. WIREs Computational Statistics, 3(2), 149–162. https://doi.org/10.1002/wics.142

Chikwira, C., & Mohammed, J. I. (2023). The Impact of the Stock Market on Liquidity and Economic Growth: Evidence of Volatile Market. Economies, 11(6), 155. https://doi.org/10.3390/economies11060155

De Araujo, F. H. A., & Fernandes, L. H. S. (2021). MULTIFRACTAL DETRENDED FLUCTUATIONS ANALYSIS FOR IBOVESPA ASSETS. Fractals, 29(07). https://doi.org/10.1142/s0218348x21501838

Dong, P., Shi, Z., & Wang, X. (2024). Financial market trend prediction model based on LSTM neural network algorithm. Journal of Computational Methods in Sciences and Engineering, 24(2), 745–755. https://doi.org/10.3233/jcm-237097

Echenausía-Monroy, J. L., Huerta-Cuellar, G., Campos, E., Jaimes-Reátegui, R., & García-López, J. H. (2022). Deterministic Brownian-like Motion: Electronic Approach. Electronics, 11(18), 2949. https://doi.org/10.3390/electronics11182949

Fathali, Z., Kodia, Z., & Ben Said, L. (2022). Stock Market Prediction of NIFTY 50 Index Applying Machine Learning Techniques. Applied Artificial Intelligence, 36(1). https://doi.org/10.1080/08839514.2022.2111134

Fuentes, M. A., Gerig, A., & Vicente, J. (2009). Universal Behavior of Extreme Price Movements in Stock Markets. PLoS ONE, 4(12), e8243. https://doi.org/10.1371/journal.pone.0008243

Galper, J. (2001). Three Business Models for the Stock Exchange Industry. The Journal of Investing, 10(1), 70–78. https://doi.org/10.3905/joi.2001.319454

Garcin, M. (2021). Forecasting with fractional Brownian motion: a financial perspective. Quantitative Finance, ahead-of-print(ahead-of-print), 1495–1512. https://doi.org/10.1080/14697688.2022.2071758

Glück, A., Ilijić, S., & Hüffel, H. (2009). Canonical active Brownian motion. Physical Review E, 79(2). https://doi.org/10.1103/physreve.79.021120

Holakouie-Naieni, K., Sepandi, M., Eshrati, B., Nematollahi, S., & Alimohamadi, Y. (2024). Comparative performance of hybrid model based on discrete wavelet transform and ARIMA models in prediction incidence of COVID-19. Heliyon, 10(13), e33848. https://doi.org/10.1016/j.heliyon.2024.e33848

Htun, H. H., Petkov, N., & Biehl, M. (2024). Forecasting relative returns for S&P 500 stocks using machine learning. Financial Innovation, 10(1). https://doi.org/10.1186/s40854-024-00644-0

Ichiba, T., Pang, G., & Taqqu, M. S. (2021). Path Properties of a Generalized Fractional Brownian Motion. Journal of Theoretical Probability, 35(1), 550–574. https://doi.org/10.1007/s10959-020-01066-1

Karp, A., & Van Vuuren, G. (2019). INVESTMENT IMPLICATIONS OF THE FRACTAL MARKET HYPOTHESIS. Annals of Financial Economics, 14(01), 1950001. https://doi.org/10.1142/s2010495219500015

Khan, A. H., Ali, A., Zahid, Z. U., Zafar, M. H., Shahid, R., Jan, T., Shah, A., & Sharif, M. U. (2023). A performance comparison of machine learning models for stock market prediction with novel investment strategy. PloS One, 18(9), e0286362. https://doi.org/10.1371/journal.pone.0286362

Khan, A., Khan, M. J., Khan, A. Q., Rahman, Z. U., & Khan, M. Y. (2021). Testing the weak form of efficient market hypothesis for socially responsible and Shariah indexes in the USA. Journal of Islamic Accounting and Business Research, 12(5), 625–645. https://doi.org/10.1108/jiabr-02-2020-0055

Khuntia, S., & Pattanayak, J. K. (2017). Dynamics of Indian Foreign Exchange Market Efficiency: An Adaptive Market Hypothesis Approach. Indian Journal of Finance, 11(9), 39. https://doi.org/10.17010/ijf/2017/v11i9/118088

Kilic, E., Yavuz, E., Pazarci, S., & Kar, A. (2023). Analyzing the efficient market hypothesis with asymmetric persistence in cryptocurrencies: Insights from the Fourier non- linear quantile unit root approach. Finance Research Letters, 58, 104528. https://doi.org/10.1016/j.frl.2023.104528

Kulkarni, S., Pharasi, H. K., Vijayaraghavan, S., Kumar, S., Chakraborti, A., & Samal, A. (2024). Investigation of Indian stock markets using topological data analysis and geometry-inspired network measures. Physica A: Statistical Mechanics and Its Applications, 643, 129785. https://doi.org/10.1016/j.physa.2024.129785

Lin, Z., & Zhang, L.-X. (2017). Convergence to a self-normalized G-Brownian motion. Probability, Uncertainty and Quantitative Risk, 2(1). https://doi.org/10.1186/s41546-017- 0013-8

Liu, Z., & Huang, S. (2020). Carbon option price forecasting based on modified fractional Brownian motion optimized by GARCH model in carbon emission trading. The North American Journal of Economics and Finance, 55, 101307. https://doi.org/10.1016/j.najef.2020.101307

Maragó, O. M., Denti, P., Iatì, M. A., Privitera, G., Gucciardi, P. G., Jones, P. H., Borghese, F., Calogero, G., Ferrari, A. C., Bonaccorso, F., Saija, R., & Nicolosi, V. (2010). Brownian Motion of Graphene. ACS Nano, 4(12), 7515–7523. https://doi.org/10.1021/nn1018126

Mallikarjuna, M., & Rao, R. P. (2019). Evaluation of forecasting methods from selected stock market returns. Financial Innovation, 5(1). https://doi.org/10.1186/s40854-019-0157-x

Maloumian, N. (2022). Unaccounted forms of complexity: A path away from the efficient market hypothesis paradigm. Social Sciences & Humanities Open, 5(1), 100244. https://doi.org/10.1016/j.ssaho.2021.100244

Meng, X., Zhang, J.-W., & Guo, H. (2016). Quantum Brownian motion model for the stock market. Physica A: Statistical Mechanics and Its Applications, 452, 281–288. https://doi.org/10.1016/j.physa.2016.02.026

Metzler, R. (2019). Brownian motion and beyond: first-passage, power spectrum, non-Gaussianity, and anomalous diffusion. Journal of Statistical Mechanics: Theory and Experiment, 2019(11), 114003. https://doi.org/10.1088/1742-5468/ab4988

Mian, T. S. (2023). Evaluation of Stock Closing Prices using Transformer Learning. Engineering, Technology & Applied Science Research, 13(5), 11635–11642. https://doi.org/10.48084/etasr.6017

Mockus, J., & Raudys, A. (2010). On the Efficient-Market Hypothesis and stock exchange game model. Expert Systems With Applications, 37(8), 5673–5681. https://doi.org/10.1016/j.eswa.2010.02.043

MUNIR, Q., FUROUKA, F., CHING, K. S., & MANSUR, K. (2012). THE EFFICIENT MARKET HYPOTHESIS REVISITED: EVIDENCE FROM THE FIVE SMALL OPEN ASEAN STOCK MARKETS. The Singapore Economic Review, 57(03), 1250021. https://doi.org/10.1142/s021759081250021x

Olorunnimbe, K., & Viktor, H. (2024). Towards efficient similarity embedded temporal Transformers via extended timeframe analysis. Complex & Intelligent Systems, 10(4), 4793–4815. https://doi.org/10.1007/s40747-024-01400-8

Orquín-Serrano, I. (2020). Predictive Power of Adaptive Candlestick Patterns in Forex Market. Eurusd Case. Mathematics, 8(5), 802. https://doi.org/10.3390/math8050802 Pagliaro, A. (2023). Forecasting Significant Stock Market Price Changes Using Machine Learning: Extra Trees Classifier Leads. Electronics, 12(21), 4551. https://doi.org/10.3390/electronics12214551

Ramadan, M. S., Abuelgasim, A., & Al Hosani, N. (2024). Advancing air quality forecasting in Abu Dhabi, UAE using time series models. Frontiers in Environmental Science, 12. https://doi.org/10.3389/fenvs.2024.1393878

Rath, S., Pattanayak, B. K., & Das, N. R. (2024). An Analytic Review on Stock Market Price Prediction using Machine Learning and Deep Learning Techniques. Recent Patents on Engineering, 18(2). https://doi.org/10.2174/1872212118666230303154251

Rossi, M. (2015). The efficient market hypothesis and calendar anomalies: a literature review. International Journal of Managerial and Financial Accounting, 7(3/4), 285. https://doi.org/10.1504/ijmfa.2015.074905

Salameh, S., & Ahmad, A. (2020). A critical review of stock market development in India. Journal of Public Affairs, 22(1). https://doi.org/10.1002/pa.2316

Savitskii, A. V. (2019). Method for Estimating the Hurst Exponent of Fractional Brownian Motion. Doklady Mathematics, 100(3), 564–567. https://doi.org/10.1134/s1064562419060188

Sharma, S., & Vishwamittar, V. (2005). Brownian motion problem: Random walk and beyond. Resonance, 10(8), 49–66. https://doi.org/10.1007/bf02866746

Shmilovici, A., Alon-Brimer, Y., & Hauser, S. (2003). Using a Stochastic Complexity Measure to Check the Efficient Market Hypothesis. Computational Economics, 22(2/3), 273–284. https://doi.org/10.1023/a:1026198216929

Shmilovici, A., & Ben-Gal, I. (2012). Predicting Stock Returns Using a Variable Order Markov Tree Model. Studies in Nonlinear Dynamics & Econometrics, 16(5). https://doi.org/10.1515/1558-3708.1648

Singh, H., & Malhotra, M. (2024). Stock market and securities index prediction using artificial intelligence: A systematic review. Multidisciplinary Reviews, 7(4), 2024060. https://doi.org/10.31893/multirev.2024060

Soekirno, S., Prabowo, M. A., Ananda, N., Santoso, B., Yulizar, D., Adi, S. P., & Wicaksana, H. S. (2024). Design of drought early warning system based on standardized precipitation index prediction using hybrid ARIMA-MLP in Banten province. IAES International Journal of Artificial Intelligence (IJ-AI), 13(2), 1878. https://doi.org/10.11591/ijai.v13.i2.pp1878-1887

Song, I., Douthett, E. B., & Jung, K. (2003). THE ROLE OF ACCOUNTING INFORMATION IN STOCK MARKET LIBERALIZATION: EVIDENCE FROM KOREA. Advances in International Accounting, 16, 67–84. https://doi.org/10.1016/s0897- 3660(03)16004-7

Strickland, C. (1996). A comparison of diffusion models of the term structure. *The European Journal of Finance*, *2*(1), 103-123.

Udoye, A. M., Akinola, L. S., & Ogbaji, E. O. (2020). Extension of Vasicek model to the modelling of interest rate. *FUDMA Journal of Sciences*, 4(2), 151–155. https://doi.org/10.33003/fjs-2020-0402-94

Vácha, L., & Vošvrda, M. S. (2005). Dynamical Agents' Strategies and the Fractal Market Hypothesis. Prague Economic Papers, 14(2), 163–170. https://doi.org/10.18267/j.pep.260

Vasicek, O. A. (2007). The Heath, Jarrow, Morton Model. Economic Notes, 36(3), 205–207. https://doi.org/10.1111/j.1468-0300.2007.00183.x

Wang, C., Xin, J., Du, Y., Shi, Y., & Sun, F. (2024). The effects of manager sentiment in financial disclosure: Perspectives of operational efficiency and market reaction. Finance Research Letters, 64, 105425. https://doi.org/10.1016/j.frl.2024.105425

Xu, X., Zhang, Y., Mcgrory, C. A., Wu, J., & Wang, Y.-G. (2023). Forecasting stock closing prices with an application to airline company data. Data Science and Management, 6(4), 239–246. https://doi.org/10.1016/j.dsm.2023.09.005

Yun, Y., & Gao, L. (2020). Pricing and Analysis of European Chooser Option Under The Vasicek Interest Rate Model. International Journal of Theoretical and Applied Mathematics, 6(2), 19. https://doi.org/10.11648/j.ijtam.20200602.11

Zhang, W., & Lu, B. (2024). Stock Trend Prediction with Machine Learning: Incorporating Inter-Stock Correlation Information through Laplacian Matrix. Big Data and Cognitive Computing, 8(6), 56. https://doi.org/10.3390/bdcc8060056

ANALYZING LONG-RUN RELATIONSHIPS AMONG LEADING STOCKS SECTORS

Jongrak Dangfoo[A], Voranon Khundilokkamol[B], Adirek Vajrapatkul[C]

ABSTRACT

This research examines the relationships among key stock sectors to determine the presence of long-term equilibrium connections. The objective is to assess both short-term and long-term interdependencies within seven sectors, namely energy, financial services, healthcare, industrial, real estate, technology, and utilities, using daily data from July 2019 to July 2024. Johansen cointegration tests were employed within a Vector Autoregression (VAR) framework to evaluate long-term relationships among the sectors. The findings indicate that all series were non-stationary at their levels but achieved stationarity after first differencing. Despite significant short-term correlations, the Johansen tests revealed no cointegrating vectors, indicating that while short-term interconnectedness exists, stable long-term relationships are absent across the sectors. Impulse response analysis demonstrated that shocks in the technology sector, especially Apple Inc., significantly impacted financial and healthcare sectors, whereas energy and utilities showed lower sensitivity. Granger causality tests confirmed bidirectional influences between specific stocks, suggesting sectoral interdependencies in the short term. The results suggest that sector-specific factors and market conditions may disrupt uniform long-term integration. The implications for investors include the need for targeted risk management strategies to address the varying sensitivity of sectors to systemic shocks. Monitoring highly interconnected sectors like technology, finance, and healthcare is essential for mitigating contagion risks during market volatility.

Keywords: *Stocks Sectors, short run relationship, long run relationship, Impulse responds analysis, Johansen cointegration tests, Vector Autoregression (VAR) model*

INTRODUCTION

Stocks represent ownership shares in publicly traded companies, serving as crucial instruments for companies and investors. Stocks provide companies with a means to raise capital for growth and expansion by selling ownership stakes to the public through initial public offerings (IPOs) and subsequent share issuances. This mechanism allows businesses to pool society's savings and selectively channel them to companies with the best investment prospects (Hughes & Singh, 1987). For investors, stocks offer opportunities to participate in

[A] *Academician, Faculty of Research and Development, V. Mane Fils (Thailand) Co., Ltd., Thailand. E- mail:Jongrak_D@yahoo.com Orcid: https://orcid.org/0000-0002-0627-8439*
[B] *Academician, Teaching, Faculty of Management Science, Pacific Institute of Management Science, Thailand. E-mail:Jued@live.com Orcid: https://orcid.org/0000-0002-0627-8439*
[C] *PhD in Economics, School of Economics, Sukhothai Thammathirat Open University, Thailand. E-mail: a.vajrapatkul@gmail.com Orcid: https://orcid.org/0000-0002-0627-8439*

a company's growth and potentially earn returns through capital appreciation and dividends. The importance of stocks extends beyond individual companies and investors. They are fundamental components of the financial system, providing a means for the economy to allocate resources efficiently.

Understanding the relationships between stocks benefits investors in improving portfolio diversification, which leads to better investment decisions, improved risk management, and more accurate market predictions. By understanding how different stocks move about each other, investors can create more balanced portfolios that reduce risk. For instance, Chong et al. (2003) suggest potential benefits of international diversification for Australian investors based on correlation statistics with major international stocks. Similarly, Cai et al. (2017) demonstrate that oil can reduce risk in the short run when combined with East Asian stocks, although this benefit decreases over the long term. Furthermore, Shan et al. (2022) demonstrate that including mainland China stocks in an international portfolio increases its Sharpe ratio, providing valuable diversification benefits.

However, the relationships between stocks are not static and can change over time. Yang et al. (2023) highlight that due to stock data's high volatility and randomness, the correlation between stocks is dynamic, making static correlation stock sets often inconsistent with reality. This emphasizes the importance of using dynamic models to capture these changing relationships accurately. In this case, traditional methods of assessing stock relationships may be insufficient. Guo et al. (2018) argue that nonlinear relationships exist between stock prices, which are not captured by the commonly used Pearson correlation coefficient. The study proposes using mutual information to characterize these nonlinear relationships, resulting in a more effective approach to measuring stock relationships in markets with large price fluctuations. Thus, some scholars applied new methods to measure this relationship, e.g., Ma et al. (2022) introduced the attribute-driven fuzzy hypergraph network (AFHGN) to enhance stock ranking prediction by analyzing complex group-wise relationships between stocks, aiding investors in making better decisions.

Researchers extensively study the relationships between stocks in the stock market using various methodologies. The primary approaches include correlation-based methods, which are widely used, with the Pearson correlation coefficient being the dominant measure (Guo et al., 2018). However, recognizing the potential for nonlinear relationships in stock prices, some researchers have employed mutual information to characterize these nonlinear relationships more effectively (Guo et al., 2018; Yang et al., 2014). These methods are often used to construct stock correlation networks, which provide insights into the underlying structure of the market (Guo et al., 2018; Guo et al., 2021; Xi & An, 2017). Some studies have proposed innovative methods like the partial correlation network to identify influential stocks driving market correlations (Kenett et al., 2010).

Identifying long-run relationships between stocks and related variables helps in understanding market dynamics and interdependencies. Long-run relationships reveal how different stocks or market segments move together over time, providing insights into market integration and segmentation (Gil-Alana et al., 2020). This knowledge is valuable for portfolio diversification and risk management strategies. Also, the long-run relationships can indicate market efficiency and potential arbitrage opportunities. Previous studies, most often try to identify long-run relationships between stocks and several variables. For instance, studies have found long-run relationships between stock prices and GDP (Österholm, 2016), exchange rates (Tsagkanos & Siriopoulos, 2013), and inflation (Albulescu et al., 2016). Albulescu et al. (2016) discovered the relation between inflation and its uncertainty negatively impact stock prices in the long run, contrary to the well-known Fisher effect. In contrast, some studies, try to identify the long run relationship involve with individuals' stock, group of stock, and stock sector (Qi

et al., 2022) and stock indices (Bouri et al., 2023).

The motivation for this research arises from the dynamic nature of stock relationships and the evolving complexities in financial markets. Prior studies often concentrated on linear correlations or static relationships, which may not accurately capture the interdependencies among sectors over time due to high volatility and sector- specific factors. This research aims to analyze both short-term and long-term relationships among key stock sectors using Johansen cointegration tests within a Vector Autoregression (VAR) framework. This approach contributes to understanding the intersectoral relationships, which is valuable for investors in developing targeted risk management strategies and optimizing diversification. The structure of this paper is as follows. The second section explores pertinent concepts related to this research. Section 3 outlines the research methodology employed in this study. Subsequently, the analysis results and discussions are presented.

LITERATURE REVIEW

This section provides an overview of theories and empirical studies relevant to analyzing long-term relationships in stock markets. It begins with Market Integration Theory, which explains how economic integration influences stock price convergence across sectors. Next, Modern Portfolio Theory is discussed, emphasizing diversification benefits. The review also explores the Contagion Effect, highlighting how market disturbances spread across sectors during crises. Lastly, some empirical studies that examining stock relationships are presented.

Market Integration Theory

Market Integration Theory scrutinizes the process and outcomes of merging separate markets into a cohesive system, considering both financial and economic facets of integration across and within national boundaries. This theory challenges the traditional notion of uniform national markets by acknowledging internal disparities and heterogeneities (Grahl & League, 1992). The effects of market integration vary based on the source of economic shocks. For example, heightened financial market integration can increase volatility when shocks originate from money markets but decrease volatility when shocks stem from real demand or supply (Sutherland, 1996).

Market Integration Theory provides a robust framework for understanding the complex interplay between markets as they become more interconnected. It posits that integrated markets lead to price and economic condition convergence across regions (Romero et al., 2019). The theory encompasses several key dimensions, i.e., Economic Integration which defined by common cash-flow dynamics across markets (Akbari et al., 2020), Financial Integration which characterized by shared risk-pricing dynamics (Akbari et al., 2020), Labor Market Integration which involves reducing segmentation and facilitating freer worker movement across regions (Wang & Zhang, 2024), with complex effects on sectors such as tourism, and Spatial Market Integration which particularly significant in agri-food markets, enhancing market efficiency and economic development by fostering regional competitiveness (Roman & Kroupová, 2022).

Contrary to conventional globalization theory, market integration does not always result in uniform outcomes. For instance, the European food and beverage sector still experiences significant price differentials despite increased economic integration, influenced by factors such as income, store productivity, and market concentration (Romero et al., 2019). However, this theory offers a comprehensive framework for understanding the intricate dynamics of merging separate markets, with significant implications for policy-making, economic development, and market efficiency across diverse sectors and regions.

Modern Portfolio Theory (MPT)

Modern Portfolio Theory (MPT) is a cornerstone of finance, addressing optimal asset allocation to maximize returns while minimizing risk. Developed by Harry Markowitz in 1952, MPT posits that investors can construct portfolios to optimize expected returns for a given level of risk (Arici et al., 2018; Müller, 1989). The theory assumes that asset prices follow a random walk in an efficient market and leverages two main criteria, i.e., expected return and portfolio variance (Müller, 1989; Xidonas et al., 2010). Central to MPT is the concept of diversification, which suggests that combining assets with varying risk-return profiles can reduce overall portfolio risk without sacrificing expected returns (Fabozzi et al., 2002). MPT's influence extends beyond financial assets to areas like timberland investments, fisheries management, and IT project selection (Busby et al., 2019; Lopetegui & Valle, 2022; Tu et al., 2019).

Nonetheless, critics argue that MPT may fail to protect against tail risk and can underallocate to high-returning asset classes in certain scenarios (Lagnado & Taleb, 2022). Recent studies have explored combining MPT with approaches like reinforcement learning and deep learning to enhance portfolio optimization (Jang & Seong, 2023; Tayalı, 2020). Furthermore, as a single-period model, it may not fully account for the unique characteristics of certain assets, such as real estate, which involve liquidity risk, horizon-dependent returns, and high transaction costs (Cheng et al., 2017). Additionally, MPT has been criticized for conflating uncertainty with risk by using volatility as a proxy (Cohen & Natoli, 2003).

Despite these limitations, MPT remains integral to investment theory and practice. Researchers have proposed extensions and alternatives to address its shortcomings, such as incorporating multi-period utility maximization, considering transaction costs, and integrating behavioral finance principles (Cheng et al., 2017; Curtis, 2004; Qu, 2019). Ongoing research seeks to refine and expand its applications. New methodologies, such as using Conditional Value-at-Risk instead of conventional mean-variance optimization, are being developed to address its limitations and improve its effectiveness in various contexts (Lopetegui & Valle, 2022; Sharma & Cho, 2019).

Contagion Effect

Financial contagion refers to the rapid spread of market disturbances from one country to another, characterized by simultaneous movements in exchange rates, stock prices, sovereign spreads, and capital flows (Dungey et al., 2006). This phenomenon affects both developed and emerging markets, transcending geographical borders and asset types (Bello et al., 2022; Dungey et al., 2006). Unlike normal market interdependence or "slow-burn" spillover, financial contagion occurs swiftly, often described as "fast and furious," where shocks in one market instantly impact others (Wu et al., 2014). This effect is particularly pronounced during crises such as the global financial crisis, European debt crisis, Brexit, and the COVID-19 pandemic (Bello et al., 2022; Escribano & Íñiguez, 2020). Contagion does not always correlate with fundamental economic health or trade and financial linkages between economies (Dungey et al., 2006). For instance, the Brexit process affected global financial markets beyond the UK and Europe (Escribano & Íñiguez, 2020). Similarly, the Greek debt crisis impacted not only neighboring countries but also distant markets (Philippas & Siriopoulos, 2013; Trabelsi & Hmida, 2018). Understanding financial contagion is crucial for market participants and regulators in preventing and managing financial crises (Su & Xu, 2021).

Contagion influences portfolio risk management, monetary and fiscal policy formulation, strategic asset allocation, and pricing (Ercan & Karahanoğlu, 2019). The contagion effect varies across different events, with non-economic events like pandemics often causing

widespread impact (Iwanicz-Drozdowska et al., 2021). During crises, volatility transmission between markets significantly increases, underscoring the importance of monitoring and managing contagion risks in an interconnected global financial system (Davidescu et al., 2023).

Financial contagion, also known as the contagion effect, involves the propagation of shocks or crises from one market or country to others, leading to heightened correlation and interconnectivity during periods of economic instability (Hansen, 2021). This phenomenon spreads financial distress across markets, actors, or investment strategies through various channels, including financial markets and bank lending (Ahelegbey et al., 2020). It is often associated with irrational behavior in financial markets, highlighting the issues of proximity and connectivity among market actors (Hansen, 2021). While these connections enable market efficiency, they also increase the risk of contagion.

The concept of contagion has evolved over time. In the late 19th and early 20th centuries, it primarily described seemingly irrational market behavior (Hansen, 2021). Today, it is applied more broadly to understand systemic risks and the spread of financial crises. For instance, the Brexit process and the COVID-19 pandemic have been studied as catalysts for financial contagion across global markets (Escribano & Íñiguez, 2020; Yarovaya et al., 2022).

The contagion effect is critical in understanding how financial crises spread across interconnected markets. It emphasizes the importance of studying systemic risks, market interdependencies, and the channels through which shocks propagate. This knowledge is essential for market participants and regulators in developing strategies to mitigate the impact of financial crises and maintain market stability (Su & Xu, 2021).

Regarding empirical research on stock relationships, various methodologies have been employed. Numerous studies have examined correlations between stock returns, volatility, and trading volume. For instance, research on the Brazilian stock market identified both contemporaneous and dynamic relationships between stock returns and trading volume, as well as between return volatility and trading volume (Medeiros & Doornik, 2008). This suggests a mutual influence among these variables, though with limited predictive power. Scholars have explored alternative methods to measure stock relationships beyond the traditional Pearson correlation coefficient. A study on the Shanghai Stock Exchange demonstrated that mutual information could be more effective, particularly in markets with significant price fluctuations (Guo et al., 2018). Additionally, another study introduced maximum likelihood estimation to select threshold values for each stock, balancing stock degree and network connectivity in correlation-based networks (Guo et al., 2021). Other studies propose innovative methods for constructing stock relationship networks and examining the impact of market liquidity's structural migration on stock relationships (Guo et al., 2021; Tang et al., 2022). Research on the interconnections among Chinese energy stocks, renewable energy stocks, and commodity markets has employed time-frequency connectedness and causality-in-quantiles methodologies. These findings indicate that while energy stock markets are vulnerable to external influences in the long term, they play a significant role in the short term. Specifically, petrochemical stocks substantially impact commodity markets, whereas renewable energy stocks have minimal influence (Chen & Qi, 2024).

DATA AND METHODOLOGY

Johansen cointegration tests are widely used statistical methods for analyzing long-run relationships between multiple time series variables. These tests are particularly useful in econometrics and financial analysis to determine if two or more non-stationary time series are cointegrated. The Johansen approach involves testing for cointegration using a vector

autoregression (VAR) framework. It can identify multiple cointegrating relationships and is generally considered more powerful than single-equation methods like the Engle-Granger test (Gonzalo & Lee, 1998). The tests use maximum likelihood estimation to determine the number of cointegrating vectors in a VAR model. Johansen cointegration tests have been applied to various economic relationships, e.g., examining the Balassa-Samuelson hypothesis (Rault & Drine, 2008), analyzing relationships between energy consumption, economic growth, and other macroeconomic variables (Habib et al., 2019; Hatzigeorgiou et al., 2010; Naser, 2015), and testing Purchasing Power Parity (Kasem & Al-Gasaymeh, 2022.)

The Vector Autoregressive (VAR) based Johansen's cointegration model (Fu & Pagani, 2012) can be represented as follows:

$$\Delta X_t = \mu + \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + ò_t \quad (1)$$

where X_t is the vector of stock index time series. Δ denotes the first difference operator. μ is a vector of constants. Γ_i are coefficient matrices for the lagged differences. K is the number of lags. $ò_t$ is the error term. The matrix Π can be decomposed as $\Pi = \alpha\beta$, where α represents the adjustment coefficients, indicating how deviations from the equilibrium relationship are corrected. β represents the cointegration vectors that define the long-run equilibrium relationships.

Johansen's Tests for Cointegration involves two statistics, i.e., the trace statistic and the maximum eigenvalue statistic, which can be written by:

$$\text{Trace} = -T \sum_{i=r+1}^{n} \ln(l - \hat{\lambda}_i), \quad (2)$$

$$\lambda_{\max} = -T\ln(\text{l} - \hat{\lambda}_{r+1}), \quad (3)$$

where T is the sample size, and $\hat{\lambda}_i$ are the estimated eigenvalues of the Π matrix.

In this study, the stock index to be investigated includes the sector's top trading stock, which was selected to represent each sector. The selected 7 stocks included Texas Gulf Energy, Incorporated (TXGE), which represents the energy sector, while Berkshire Hathaway Inc. (BRK-B) represents the financial sector. Eli Lilly and Company (LLY) represents the healthcare sector, and GE Aerospace (GE) stands for the industrial sector. Prologis, Inc. (PLD) represents the real estate sector, with Apple Inc. (AAPL) representing the technology sector. Lastly, NextEra Energy, Inc. (NEE) represents the utilities sector. This research utilizes daily data from Yahoo Finance, covering the period from July 29, 2019, to July 26, 2024.

RESULTS

This section provides the analysis results of the selected stock sector representatives. The findings detail both short-term and long-term dynamics and the significance of their responses to shocks. Table 1 provides a descriptive statistical analysis.

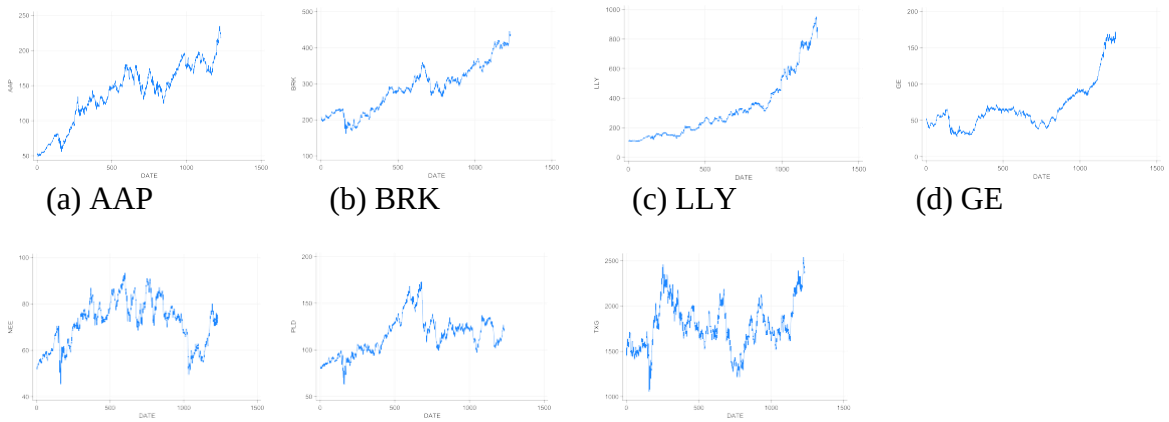
Table 1 – Descriptive statistics

Variable	Mean	Std. dev.	Min	Max
AAP	139.194	42.086	49.250	234.820
BRK	287.553	66.007	162.130	445.610
LLY	326.547	206.060	106.920	950.460
GE	67.899	32.218	27.363	172.000
NEE	71.756	10.046	45.415	93.360
PLD	115.237	20.608	62.820	173.010
TXG	1,780.374	260.651	1,055.910	2,537.840

Table 2 – Augmented Dickey-Fuller Unit Root Tests

test stat.	At level		First order difference	
	t-Statistic	Prob.	t-Statistic	Prob.
AAP	-1.258	0.6482	-35.965	0.000
BRK	0.109	0.9667	-37.540	0.000
LLY	1.168	0.9958	-33.734	0.000
GE	1.987	0.9987	-36.690	0.000
NEE	-2.655	0.0821	-36.255	0.000
PLD	-2.151	0.2247	-34.921	0.000
TXG	-2.491	0.1176	-35.439	0.000

Table 2 shows that at the level, none of the sectors exhibit significant results to reject the null hypothesis of a unit root, suggesting that the series are non-stationary. However, after first differencing, all variables display highly significant t-statistics with p-values of 0.000, indicating that they become stationary. Figure 1 shows the stock price data series.



(a) AAP (b) BRK (c) LLY (d) GE

(e) NEE (f) PLD (g) TXG

Figure 1 – Stock price data series

Table 3 – Correlation matrix

	AAP	BRK	LLY	GE	NEE	PLD	TXG
AAP	1.0000	0.8886	0.7872	0.6587	0.3930	0.7120	0.3020
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BRK	0.8886	1.0000	0.9106	0.8418	0.1487	0.6018	0.2443
p-value	0.0000	0.0000	0.0000	0.0000	0.0036	0.0000	0.0000
LLY	0.7872	0.9106	1.0000	0.9027	-0.0829	0.3122	0.2819
p-value	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
GE	0.6587	0.8418	0.9027	1.0000	-0.1112	0.2294	0.3802
p-value	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000
NEE	0.3930	0.1487	-0.0829	-0.1112	1.0000	0.5973	0.1001
p-value	0.0000	0.0036	0.0001	0.0004	0.0000	0.0000	0.0000
PLD	0.7120	0.6018	0.3122	0.2294	0.5973	1.0000	0.1387
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TXG	0.3020	0.2443	0.2819	0.3802	0.1001	0.1387	1.0000
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The correlation matrix in Table 3 shows the relationships among the selected stock sectors. AAP has a strong positive correlation with BRK (0.8886), LLY (0.7872), and PLD (0.7120), indicating that these sectors tend to move together. A moderate correlation exists between AAP and GE (0.6587), while its correlation with NEE (0.3930) and TXG (0.3020) is weaker. BRK also strongly correlates with LLY (0.9106) and GE (0.8418), suggesting a significant comovement among these sectors. However, its correlation with NEE (0.1487) and TXG (0.2443) is much lower, indicating less association. LLY is highly correlated with GE (0.9027) and moderately correlated with PLD (0.3122) while showing a slight negative correlation with NEE (-0.0829). GE exhibits a similar pattern with strong positive correlations with LLY and BRK but a weaker or negative relationship with NEE (-0.1112). NEE has moderate positive correlations with PLD (0.5973) and TXG (0.1001), while PLD shows only a modest relationship with TXG (0.1387). This matrix highlights strong comovement among AAP, BRK, LLY, and GE, with weaker relationships involving NEE and TXG

To conduct Johansen tests, the number of lags is identified in Table 4 which indicates that the model's best fit is achieved with 1 lag.

Table 4 – Lag-order selection criteria

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-41,206.700				3.3e+20	67.123	67.134	67.152
1	-22,843.500	36,726.000	49.000	-	3.7e+07*	37.296 *	37.383 *	37.529 *
2	-22,805.700	75.474	49.000	0.009	3.8e+07	37.314	37.478	37.751
3	-22,766.300	78.970	49.000	0.004	3.8e+07	37.329	37.580	37.971
4	-22,729.600	73.401 *	49.000	0.014	3.9e+07	37.349	37.668	38.195

Table 5 – Johansen tests for cointegration

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	7	-22,942.040		94.595	124.240
1	20	-22,927.283	0.024	65.082	94.150
2	31	-22,916.793	0.017	44.102	68.520
3	40	-22,908.752	0.013	28.026	47.210
4	47	-22,902.934	0.009	16.383	29.680
5	52	-22,899.244	0.008	7.005	15.410
6	55	-22,895.296	0.005	1.109	3.760
7	56	-22,894.742	0.001	0.376	

The Johansen cointegration test in Table 5 indicates that there is no presence of cointegrating vectors. Thus, the next step is to estimate VAR model.

Table 6 – Vector Autoregressive (VAR) model summary

Equation	Parms	RMSE	R-sq	chi2	P>chi2
AAP	8	2.595	0.996	323,488.700	0.000
BRK	8	3.433	0.997	456,331.600	0.000
LLY	8	7.070	0.999	1,050,372.000	0.000
GE	8	1.576	0.998	516,371.000	0.000
NEE	8	1.296	0.983	72,980.640	0.000
PLD	8	2.142	0.989	113,275.400	0.000
TXG	8	42.333	0.974	45,701.680	0.000
Log likelihood		-22,894.740	AIC		37.288
FPE		3.69e+07	HQIC		37.376
Det(Sigma_ml)		3.37e+07	SBIC		37.521

Table 6 indicates that the model explains a significant portion of the variation in these sectors, R-squared (R^2) values ranging from 0.974 (for TXG) to 0.999 (for LLY). All sectors show statistically significant model fit, with chi-squared (χ^2) test p-values of 0.000, suggesting that the model's parameters are highly significant. Figure 2 shows residual data series.

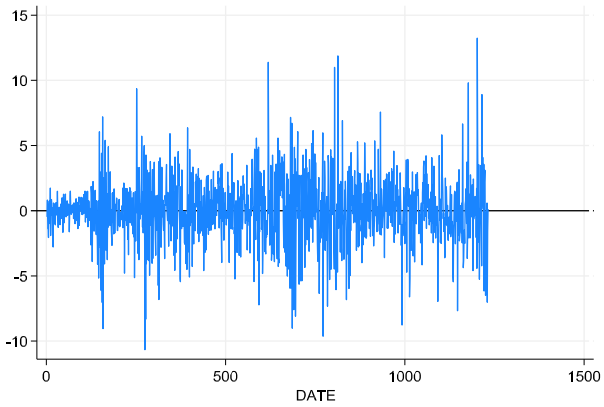


Figure 3 – residual data series

Table 8 – Jarque-Bera test

Equation	chi2	df	Prob > chi2
AAP	275.611	2.000	0.000
BRK	350.728	2.000	0.000
LLY	14,000.000	2.000	0.000
GE	5,142.720	2.000	0.000
NEE	1,561.612	2.000	0.000
PLD	439.661	2.000	0.000
TXG	108.045	2.000	0.000
ALL	22,000.000	14.000	0.000

Table 9 – Eigenvalue stability condition

Eigenvalue	Modulus
1.001599	1.0016
0.9928658 + 0.00659883i	0.992888
0.9928658 - 0.00659883i	0.992888
0.9911514	0.991151
0.9849446	0.984945
0.9760116	0.976012
0.9724755	0.972476

Table 7 indicate that the model shows signs of autocorrelation at all lags, with p-values below 0.05 for all but the first lag (p = 0.011), suggesting some degree of residual autocorrelation. The Jarque-Bera test in Table 8 indicates that the residuals for these sectors deviate significantly from normality. Table 9 assesses the stability of the VAR model and it shows that the eigenvalues range from 0.972 to 1.001, with only one eigenvalue slightly exceeding 1 (1.0016). This suggests that the model is on the borderline of stability, with most eigenvalues lying within the acceptable range. However, the eigenvalue exceeding 1 indicates a potential instability, which could affect the reliability of long-term forecasts. Figure 4 shows 900 days period response of stock price to impulse in AAP.

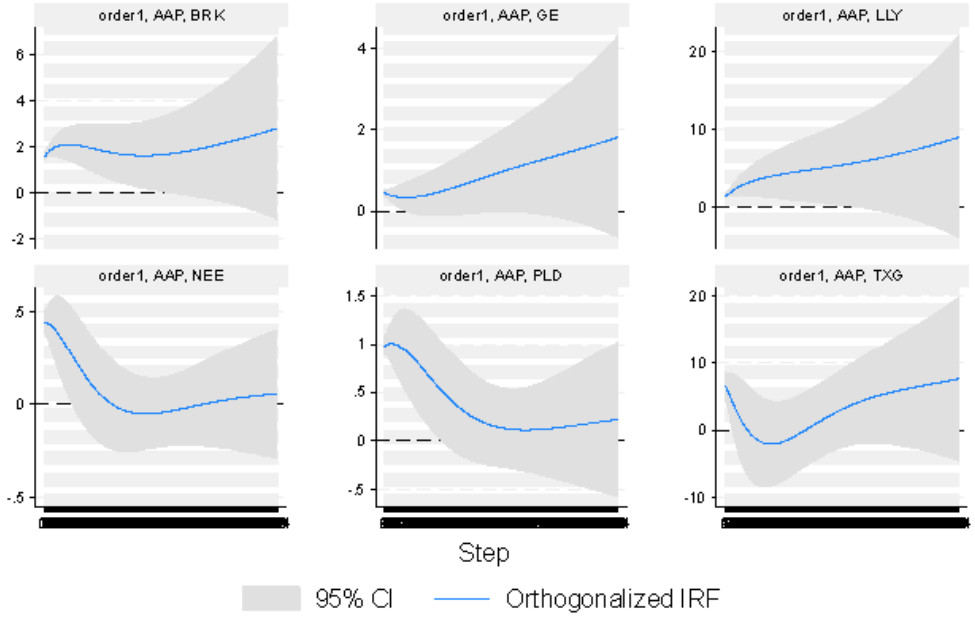


Figure 5 – 900 days period response of stock price to impulse in AAP

Figure 3 illustrates the 900-day response of stock prices in various sectors to an impulse in Apple Inc. (AAP). The stock prices of Berkshire Hathaway (BRK), Eli Lilly (LLY), General Electric (GE), NextEra Energy (NEE), Prologis (PLD), and Texas Gulf (TXG) exhibit varying degrees of responsiveness over time. BRK and LLY show a moderate and steady increase in response to the AAP shock, suggesting a consistent influence of AAP's movements on these stocks. GE and PLD also demonstrate a positive response, but the magnitude is smaller compared to BRK and LLY. In contrast, NEE and TXG experience minimal fluctuations in response to the AAP shock, indicating a lower sensitivity to AAP's price movements. The figure suggests that AAP's shocks have a significant but varied impact on the stock prices of these sectors, with BRK and LLY being the most responsive. Table 10 show the variance decomposition of the stock prices caused by shocks from AAP.

Table 10 – variance decomposition

	BRK	LLY	GE	NEE	PLD	TXG
Step	oirf	oirf	oirf	oirf	oirf	oirf
0	1.579	1.403	0.439	0.441	0.988	6.448
1	1.599	1.446	0.435	0.441	0.991	6.327
2	1.619	1.488	0.431	0.440	0.993	6.205
3	1.639	1.529	0.427	0.440	0.995	6.083
4	1.658	1.570	0.424	0.440	0.997	5.960
5	1.676	1.611	0.420	0.440	0.999	5.838
6	1.694	1.650	0.417	0.439	1.001	5.715
7	1.711	1.689	0.413	0.438	1.002	5.592
8	1.728	1.727	0.410	0.438	1.004	5.469
9	1.744	1.765	0.407	0.437	1.005	5.346
10	1.760	1.802	0.404	0.436	1.006	5.224

Table 11 – Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
AAP	BRK	3.559	1	0.059
AAP	LLY	4.382	1	0.036
AAP	GE	0.611	1	0.434
AAP	NEE	1.035	1	0.309
AAP	PLD	1.537	1	0.215
AAP	TXG	0.702	1	0.402
BRK	AAP	5.655	1	0.017
LLY	AAP	6.577	1	0.010
GE	AAP	0.037	1	0.847
NEE	AAP	1.111	1	0.292
PLD	AAP	1.756	1	0.185
TXG	AAP	0.031	1	0.860

Table 11 reveals that AAP is Granger-caused by both BRK ($chi^2 = 3.559$, $p = 0.059$) and LLY ($chi^2 = 4.382$, $p = 0.036$), indicating that past values of BRK and LLY provide valuable information for predicting AAP. However, no significant causality is found from GE, NEE, PLD, or TXG to AAP. Conversely, AAP significantly Granger-causes BRK ($chi^2 = 5.655$, $p = 0.017$) and LLY ($chi^2 = 6.577$, $p = 0.010$), suggesting that AAP's past values are useful in predicting these sectors. No significant causality is found for other sectors in relation to AAP.

These results highlight the interdependencies between specific sectors, particularly between AAP, BRK, and LLY.

DISCUSSION

The findings present a picture of the interconnected dynamics in the stock market. The results highlight the significant short-term dynamics and sectoral interdependencies. The results of the analysis demonstrate that selected sectors exhibit substantial correlations, with notable co-movements among technology (Apple Inc.), financial services (Berkshire Hathaway), and healthcare (Eli Lilly). The evidence aligns with Market Integration Theory, which posits that as markets become more interconnected, there is a convergence of prices and economic conditions across sectors (Romero et al., 2019). The strong correlations observed support the theory's assertion that financial market integration enhances the cohesiveness of different sectors within a broader market framework. However, the absence of cointegrating relationships as indicated by the Johansen cointegration test challenges the uniformity assumed by Market Integration Theory. This deviation suggests that while short-term dynamics may reflect interconnectedness, the long-term relationships might not exhibit convergence across all sectors. This finding resonates with previous studies that have found significant price differentials despite increased economic integration, as seen in the European food and beverage sector (Romero et al., 2019). The lack of long-term cointegration could indicate the presence of internal disparities or sector-specific factors that prevent complete alignment, reinforcing the theory's acknowledgment of heterogeneities within ostensibly integrated markets.

The results reveal significant correlations among certain sectors, such as technology, healthcare, and financial services, suggesting potential implications for portfolio diversification strategies. According to Modern Portfolio Theory (MPT), diversification benefits can be achieved by including assets with low or negative correlations (Markowitz, 1952). The findings support the premise of MPT to some extent, particularly in sectors like energy and utilities, which showed weaker correlations with technology and healthcare. The lower sensitivity of sectors such as NextEra Energy (NEE) to shocks in Apple Inc. aligns with the idea that diversification can reduce risk by including sectors with distinct risk-return profiles.

The study's impulse response and variance decomposition analyses underscore the varying degrees of sectoral responsiveness to shocks, particularly from technology stocks. The observation that shocks to Apple Inc. had significant but differentiated effects on sectors such as financial services (Berkshire Hathaway) and healthcare (Eli Lilly) supports the concept of financial contagion, wherein market disturbances spread rapidly across sectors (Dungey et al., 2006). These findings corroborate previous studies that demonstrate the interconnected nature of financial markets and the rapid transmission of shocks (Hansen, 2021). However, the weaker responses observed in the energy and utilities sectors suggest a differentiated level of exposure to systemic risks, indicating that not all sectors exhibit equal susceptibility to financial contagion. This pattern mirrors findings from past studies showing that non-economic events, such as pandemics, have varied impacts across sectors, with some industries experiencing more pronounced effects (Iwanicz-Drozdowska et al., 2021).

POLICY IMPLEMENTATION

The significant correlations among technology, healthcare, and financial services stocks imply that investors should implement measures to monitor systemic risks and mitigate the

potential spread of financial contagion, especially during periods of heightened market volatility. Additionally, the findings highlight the differentiated sensitivity of sectors to shocks, suggesting the importance of targeted interventions. For example, during economic crises, sectors like energy and utilities, which exhibit lower responsiveness, may require tailored support to ensure stability, while sectors with higher sensitivity, such as financial services, should be prioritized for risk management and capital adequacy measures.

FUTURE RESEARCH

Future research should consider examining the role of macroeconomic variables on the interconnectedness of different stock sectors. Additionally, future studies could employ alternative methodologies, such as machine learning techniques or nonlinear models, to capture the dynamic nature of sectoral relationships more accurately. Exploring the potential influence of emerging sectors like renewable energy or technology-driven industries on traditional sectors would also provide valuable insights into the relationships between stocks.

CONCLUSION

This research investigates the relationships among major stock sectors using Johansen cointegration tests on daily stock prices from July 2019 to July 2024. The study aims to identify both short- term and long- term interdependencies within seven sectors: energy, financial services, healthcare, industrial, real estate, technology, and utilities. The selected stocks representing these sectors provide insights into the underlying dynamics and sectoral linkages, offering a comprehensive analysis of market behavior. The findings from the Johansen tests indicate no long- term cointegrating vectors. This suggests that while the sectors exhibit some short-term interconnectedness, they do not share a stable long-term relationship. Factors unique to each sector and market- specific conditions may hinder uniform integration. However, significant short-term correlations were observed, especially between the technology, financial, and healthcare sectors, demonstrating strong co- movements. Additionally, the impulse response analysis revealed that shocks from technology stocks, particularly Apple Inc, significantly impacted the financial and healthcare sectors, whereas energy and utilities displayed weaker responses. The differentiated sensitivity among sectors suggests diverse exposure levels to systemic risks, with some sectors more susceptible to market disturbances than others. The policy implications underscore the necessity for tailored risk management strategies. Given the significant correlations among technology, financial, and healthcare stocks, investors should closely monitor these sectors to mitigate potential contagion during periods of market volatility.

REFERENCES

Ahelegbey, D. F., Giudici, P., & Hashem, S. Q. (2020). Network VAR models to measure financial contagion. The North American Journal of Economics and Finance, 55, 101318. https://doi.org/10.1016/j.najef.2020.101318

Akbari, A., Ng, L., & Solnik, B. (2020). Emerging Markets Are Catching Up: Economic or Financial Integration? Journal of Financial and Quantitative Analysis, 55(7), 2270-2303. https://doi.org/10.1017/s0022109019000681

Albulescu, C. T., Aubin, C., & Goyeau, D. (2016). Stock prices, inflation and inflation uncertainty in the U.S.: testing the long-run relationship considering Dow Jones sector indexes. Applied Economics, 49(18), 1794-1807. https://doi.org/10.1080/00036846.2016.1226491

Arici, G., Leonardi, R., Dalai, M., & Spalvieri, A. (2018). A Communication Theoretic Interpretation of Modern Portfolio Theory Including Short Sales, Leverage and Transaction Costs. Journal of Risk and Financial Management, 12(1), 4. https://doi.org/10.3390/jrfm12010004

Bello, J., Guo, J., & Newaz, M. K. (2022). Financial contagion effects of major crises in African stock markets. International Review of Financial Analysis, 82, 102128. https://doi.org/10.1016/j.irfa.2022.102128

Busby, G. M., Binkley, C. S., & Chudy, R. P. (2019). Constructing optimal global timberland investment portfolios. Forest Policy and Economics, 111, 102083. https://doi.org/10.1016/j.forpol.2019.102083

Cai, X. J., Tian, S., Yuan, N., & Hamori, S. (2017). Interdependence between oil and East Asian stock markets: Evidence from wavelet coherence analysis. Journal of International Financial Markets, Institutions and Money, 48, 206-223. https://doi.org/10.1016/j.intfin.2017.02.001

Cheng, P., Lin, Z., & Liu, Y. (2017). Optimal Portfolio Selection: The Role of Illiquidity and Investment Horizon. Journal of Real Estate Research, 39(4), 515-536. https://doi.org/10.1080/10835547.2017.12091485

Chen, Y., & Qi, H. (2024). Dynamic interplay between Chinese energy, renewable energy stocks, and commodity markets: Time-frequency causality study. Renewable Energy, 228, 120578. https://doi.org/10.1016/j.renene.2024.120578

Chong, L., Drew, M., & Veeraraghavan, M. (2003). Stock Market Interdependence: Evidence from Australia. Pacific Accounting Review, 15(2), 51-76. https://doi.org/10.1108/eb037974

Cohen, M. H., & Natoli, V. D. (2003). Risk and utility in portfolio optimization. Physica A: Statistical Mechanics and Its Applications, 324(1-2), 81-88. https://doi.org/10.1016/s0378-4371(02)01957-x

Curtis, G. (2004). Modern Portfolio Theory and Behavioral Finance. The Journal of Wealth Management, 7(2), 16-22. https://doi.org/10.3905/jwm.2004.434562

Davidescu, A., Vacaru (Boita), O., Hapau, R., Gruiescu, M., & Manta, E. (2023). Exploring the Contagion Effect from Developed to Emerging CEE Financial Markets. Mathematics, 11(3), 666. https://doi.org/10.3390/math11030666

Dungey, M., Fry, R., & Martin, V. L. (2006). Correlation, Contagion, and Asian Evidence. Asian Economic Papers, 5(2), 32-72. https://doi.org/10.1162/asep.2006.5.2.32

Ercan, H., & Karahanoğlu, İ. (2019). A Wavelet Coherence Analysis: Contagion in Emerging Countries Stock Markets. Periodica Polytechnica Social and Management Sciences, 27(2), 99-107. https://doi.org/10.3311/ppso.11512

Escribano, A., & Íñiguez, C. (2020). The contagion phenomena of the Brexit process on main stock markets. International Journal of Finance & Economics, 26(3), 4462-4481. https://doi.org/10.1002/ijfe.2025

Fabozzi, F. J., Gupta, F., & Markowitz, H. M. (2002). The Legacy of Modern Portfolio Theory. The Journal of Investing, 11(3), 7-22. https://doi.org/10.3905/joi.2002.319510

Fu, R., & Pagani, M. (2012). On the cointegration of international stock indices. Journal of Economics and Finance, 36(3), 463-480. https://doi.org/10.1007/s12197-010-9136-9

Gil-Alana, L. A., Yaya, O. S., Akinsomi, O., & Coskun, Y. (2020). How do stocks in BRICS co-move with real estate stocks? International Review of Economics & Finance, 69, 93-101. https://doi.org/10.1016/j.iref.2020.04.014

Gonzalo, J., & Lee, T.-H. (1998). Pitfalls in testing for long run relationships. Journal of Econometrics, 86(1), 129-154. https://doi.org/10.1016/s0304-4076(97)00111-5

Grahl, J., & League, P. (1992). Integration Theory and European Labour Markets. British Journal of Industrial Relations, 30(4), 515-527. https://doi.org/10.1111/j.1467-8543.1992.tb00789.x

Guo, X., Tian, T., & Zhang, H. (2018). Development of stock correlation networks using mutual information and financial big data. PLOS ONE, 13(4), e0195941. https://doi.org/10.1371/journal.pone.0195941

Guo, X., Li, W., Zhang, H., & Tian, T. (2021). Multi-likelihood methods for developing relationship networks using stock market data. Physica A: Statistical Mechanics and Its Applications, 585, 126421. https://doi.org/10.1016/j.physa.2021.126421

Hansen, K. B. (2021). Financial contagion: problems of proximity and connectivity in financial markets. Journal of Cultural Economy, 14(4), 388-402. https://doi.org/10.1080/17530350.2021.1879211

Hughes, A., & Singh, A. (1987). Takeovers and the stock market. Contributions to Political Economy, 6(1), 73-85. https://doi.org/10.1093/oxfordjournals.cpe.a035717

Iwanicz-Drozdowska, M., Rogowicz, K., Kurowski, Ł., & Smaga, P. (2021). Two decades of contagion effect on stock markets: Which events are more contagious? Journal of Financial Stability, 55, 100907. https://doi.org/10.1016/j.jfs.2021.100907

Jang, J., & Seong, N. (2023). Deep reinforcement learning for stock portfolio optimization by connecting with modern portfolio theory. Expert Systems with Applications, 218, 119556. https://doi.org/10.1016/j.eswa.2023.119556

Kasem, J., & Al-Gasaymeh, A. (2022). A COINTEGRATION ANALYSIS FOR THE VALIDITY OF PURCHASING POWER PARITY: EVIDENCE FROM MIDDLE EAST COUNTRIES. International Journal of Technology, Innovation and Management (IJTIM), 2(1). https://doi.org/10.54489/ijtim.v2i1.60

Kenett, D. Y., Madi, A., Tumminello, M., Ben-Jacob, E., Mantegna, R. N., & Gur-Gershgoren, G. (2010). Dominating Clasp of the Financial Sector Revealed by Partial Correlation Analysis of the Stock Market. PLoS ONE, 5(12), e15032. https://doi.org/10.1371/journal.pone.0015032

Lagnado, R., & Taleb, N. N. (2022). Pension Funds Should Never Rely on Correlation. The Journal of Alternative Investments, 24(4), 8-17. https://doi.org/10.3905/jai.2022.1.157

Lopetegui, I., & Del Valle, I. (2022). An efficient portfolio approach towards ecosystem-based fisheries governance in EU. Fisheries Research, 254, 106427. https://doi.org/10.1016/j.fishres.2022.106427

Ma, X., Zhao, T., Guo, Q., Li, X., & Zhang, C. (2022). Fuzzy hypergraph network for recommending top-K profitable stocks. Information Sciences, 613, 239-255. https://doi.org/10.1016/j.ins.2022.09.010

Medeiros, O. R. D., & Doornik, B. F. N. V. (2008). The Empirical Relationship Between Stock Returns, Return Volatility and Trading Volume in the Brazilian Stock Market. Brazilian Business Review, 5(1), 01-17. https://doi.org/10.15728/bbr.2008.5.1.1

Müller, H. H. (1989). Modern Portfolio Theory: Some Main Results. ASTIN Bulletin, 19(S1), 9-27. https://doi.org/10.1017/s051503610000859x

Philippas, D., & Siriopoulos, C. (2013). Putting the "C" into crisis: Contagion, correlations and copulas on EMU bond markets. Journal of International Financial Markets, Institutions and Money, 27, 161-176. https://doi.org/10.1016/j.intfin.2013.09.008

Österholm, P. (2016). The Long-run Relationship Between Stock Prices and GDP in Sweden. Economic Notes, 45(2), 283-297. https://doi.org/10.1111/ecno.12057

Qi, H., Ma, L., Peng, P., Chen, H., & Li, K. (2022). Dynamic connectedness between clean energy stock markets and energy commodity markets during times of COVID-19: Empirical evidence from China. Resources Policy, 79, 103094. https://doi.org/10.1016/j.resourpol.2022.103094

Qu, H. (2019). Risk and diversification of nonprofit revenue portfolios: Applying modern portfolio theory to nonprofit revenue management. Nonprofit Management and Leadership, 30(2), 193-212. https://doi.org/10.1002/nml.21385

Roman, M., & Žáková Kroupová, Z. (2022). Spatial Market Integration: A Case Study of the Polish-Czech Milk Market. Economies, 10(1), 25. https://doi.org/10.3390/economies10010025

Romero, J., Cruz-Roche, I., & Charron, J.-P. (2019). The myth of price convergence under economic integration: A proposed explanation for the difference in food prices across European countries. European Management Journal, 38(2), 267-276. https://doi.org/10.1016/j.emj.2019.10.002

Rault, C., & Drine, I. (2008). Does the Balassa-Samuelson Hypothesis Hold for Asian Countries? An Empirical Analysis using Panel Data Cointegration Tests. SSRN Electronic Journal, 4(4). https://doi.org/10.2139/ssrn.337100

Shan, C., Wang, S. Q., Zhang, C., & Tang, D. Y. (2022). The diversification benefits and policy risks of accessing China's stock market. Journal of Empirical Finance, 66, 155-175. https://doi.org/10.1016/j.jempfin.2022.01.001

Sharma, B. P., & Cho, S.-H. (2019). Using portfolio theory in spatial targeting of forest carbon payments: an effective strategy to address spatiotemporal variation in land-use opportunity costs? Canadian Journal of Forest Research, 50(2), 170-184. https://doi.org/10.1139/cjfr-2019-0270

Sutherland, A. (1996). Financial Market Integration and Macroeconomic Volatility. The Scandinavian Journal of Economics, 98(4), 521. https://doi.org/10.2307/3440882

Su, Z., & Xu, F. (2021). Dynamic identification of systemically important financial markets in the spread of contagion: A ripple network based collective spillover effect approach. Journal of Multinational Financial Management, 60, 100681. https://doi.org/10.1016/j.mulfin.2021.100681

Tang, Y., Xie, W., Li, D. A., & Ruan, Y. (2022). Market liquidity migration's effects on the relationship between stock liquidity and stock price crash risk: Evidence from China. The Quarterly Review of Economics and Finance, 91, 158-169. https://doi.org/10.1016/j.qref.2022.10.013

Tolun Tayalı, S. (2020). A novel backtesting methodology for clustering in mean-variance portfolio optimization. Knowledge-Based Systems, 209, 106454. https://doi.org/10.1016/j.knosys.2020.106454

Trabelsi, M. A., & Hmida, S. (2018). A Dynamic Correlation Analysis of Financial Contagion: Evidence from the Eurozone Stock Markets. Entrepreneurial Business and Economics Review, 6(3), 129-141. https://doi.org/10.15678/eber.2018.060308

Tsagkanos, A., & Siriopoulos, C. (2013). A long-run relationship between stock price index and exchange rate: A structural nonparametric cointegrating regression approach. https://doi.org/10.1016/j.intfin.2013.01.008

Tu, Y.-J., Subramanyam, R., Shaw, M. J., Huang, Y.-H., & Strader, T. J. (2019). Candidate diversity and granularity in IT portfolio construction. Information Technology and Management, 21(3), 157-168. https://doi.org/10.1007/s10799-019-00312-1

Wang, T., & Zhang, H. (2024). Nonlinear Impact of Labor Market Integration on Tourism Development: Evidence from China. Journal of China Tourism Research, ahead-of-print(ahead-of-print), 1-23. https://doi.org/10.1080/19388160.2024.2326809

Wu, L., Meng, Q., & Xu, K. (2014). 'Slow-burn' spillover and 'fast and furious' contagion: a study of international stock markets. Quantitative Finance, 15(6), 933-958. https://doi.org/10.1080/14697688.2014.952242

Yang, C., Zhu, X., Li, Q., Chen, Y., & Deng, Q. (2014). Research on the evolution of stock correlation based on maximal spanning trees. Physica A: Statistical Mechanics and Its Applications, 415, 1-18. https://doi.org/10.1016/j.physa.2014.07.069

Yang, Z., Zhao, T., Wang, S., & Li, X. (2023). MDF-DMC: A stock prediction model combining multi-view stock data features with dynamic market correlation information. Expert Systems with Applications, 238, 122134. https://doi.org/10.1016/j.eswa.2023.122134

Yarovaya, L., Brzeszczyński, J., Goodell, J. W., Lucey, B., & Lau, C. K. M. (2022). Rethinking financial contagion: Information transmission mechanism during the COVID-19 pandemic. Journal of International Financial Markets, Institutions and Money, 79(3), 101589. https://doi.org/10.1016/j.intfin.2022.101589

Xi, X., & An, H. (2017). Research on energy stock market associated network structure based on financial indicators. Physica A: Statistical Mechanics and Its Applications, 490, 1309-1323. https://doi.org/10.1016/j.physa.2017.08.114

Xidonas, P., Mavrotas, G., & Psarras, J. (2010). A multiple criteria decision-making approach for the selection of stocks. Journal of the Operational Research Society, 61(8), 1273-1287. https://doi.org/10.1057/jors.2009.74

AN INDIVIDUAL CONSUMPTION TAXATION MODEL IN MALAYSIA

Nurul Farhaini Razali[A], Hafinaz Hasniyanti Hassan[B], Analisa Hamdan[C]

ABSTRACT

This study presents a novel approach to developing an individual consumption taxation model tailored to Malaysia's economic environment. The objective was to introduce a model that integrates individual, firm and governmental behaviours within the context of Malaysia's taxation system, focusing particularly on the Goods and Services Tax (GST). By analyzing consumption patterns across different median household income groups of T20, M40 and B40, the study identified the consumption levels for the current and future periods are set to be the decision variables. The proposed model prioritized maximizing the utility function for individuals while ensuring the related budget constraints were satisfied. Notably, it underscored the impact of firm behaviours on individual utility levels and highlighted the comprehensive coverage of government consumption across both individual and firm domains. Employing the Lagrange multiplier method, the study successfully solved the model using computational tools such as Excel Solver, exploring various consumption tax rates ranging from 5 to 7 per cent. The results elucidated the burden imposed on all segments of the population by GST implementation, alongside an increase in government consumption. Optimal consumption tax rates of 5 per cent for individuals and 7 per cent for the government emerged from the analysis. Furthermore, the research considered the implications of tax reform, suggesting potential enhancements to Malaysia's taxation policy guidelines. In summary, this study presents an optimization model tailored to Malaysia's consumption taxation environment, successfully leveraging the Lagrange multiplier method for a solution. The validated utility of this model offers valuable insights for shaping future Malaysian taxation policies, serving as a pertinent guide for policymakers in the domain.

Keywords: *B40, Excel Solver, Goods and services tax, Individual Consumption Taxation, Lagrange Multiplier Method, Malaysian Taxation, M40, Optimization and T20.*

[A] *PhD, School of Technology, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: nurul.farhaini@apu.edu.my Orcid: https://orcid.org/0000-0002-3687-5154*

[B] *PhD, School of Accounting and Finance, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: hafinaz.hasniyanti@apu.edu.my Orcid: https://orcid.org/0000-0002-0187-6405*

[C] *Master, Digital Learning Hub, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: analisa@apu.edu.my Orcid: https://orcid.org/0000-0003-4225-129X*

DETERMINING THE CHALLENGES FACED BY AUDITORS WITH AUDIT AUTOMATION

Dr Ibrahim O.A. Eriqat[A], Kavitha Arunasalam[B], Suresh Kumar Kandiah[C]

ABSTRACT

Auditing is a field that amongst others, being impacted by the rapid advancement of technology. The implementation of automated accounting systems, which has been facilitated by technological advancements, has direct influence on audit industry as it promotes Audit Automation which particularly focuses on integration of technologies such as artificial intelligence (AI), robotic process automation (RPA), blockchain technologies, big data analytics and other emerging tools. The evolution of the auditing profession with advancing technologies enhances audit quality in many ways, yet it also introduces various challenges for auditors. Therefore, this study aims to investigate the audit automation challenges that auditors in Malaysia may face. This is a quantitative study, where questionnaires are distributed to a diverse group of auditors across various sectors. It considers different aspects related to audit automation that might pose challenges for auditors, including auditor skills and competencies, regulatory and compliance issues, and the integration of new technologies into the audit process. The purpose of this study to gather insight on issues auditors' face with audit automation such as the extend of complexity of these technologies. The findings of this study are expected to provide valuable insights into the barriers that auditors face when integrating automation into their work. These insights will not only contribute to the existing literature on audit automation but will also offer practical recommendations for audit firms, professional bodies, and policymakers to support auditors in navigating the challenges of the digital transformation of the auditing profession

Keywords: *Audit Automation, Automated Accounting System, Challenges, Auditors*

INTRODUCTION

Traditional audit has always been the forefront of credible financial statements reporting. But over the years with the growing complexity of business and globalisation the task of traditional audit has become more challenging and tedious. Toppled by Financial Statements fraud by several prominent companies like WorldCom and Enron further exasperated the need the evaluate the audit strategies. Sarbanes-Oxley Act of 2002 (SOX) was introduced as a guideline to conduct better ethical audits.

[A] *Asia Pacific University, School of Accounting and Finance, Kuala Lumpur, Malaysia. Email: ibrahim.eriqat@apu.edu.my Orcid: http://orcid.org/0000-0002-6777-9472*
[B] *Asia Pacific University, School of Accounting and Finance, Kuala Lumpur, Malaysia. Email: kavitha@apu.edu.my*
[C] *Asia Pacific University, School of Accounting and Finance, Kuala Lumpur, Malaysia. Email: suresh@apu.edu.my*

Despite this, Financial Statements manipulation continue to prolific in the business world for example Bernie Madoff Scandal (2008) and Lehman Brothers Scandal (2008), just to name a few. Financial Statement frauds continue exist mainly due to Financial Statements manipulation and the overwhelming workload the auditors faced with in a short duration of time.

In the era of IR 4.0 (Industrial revolution 4.0) with the advancement of technology, rapid changes are taking place in business organisations including Accounting and Audit. With the emergence of Artificial Intelligent (AI) and Audit Automation (AA) has help tremendously to streamline the entire audit process.

Audit automation refers to the use of technology mainly cloud based software to update and improve the auditing process. This includes manual data collection and processing source huge amount of data. By using Audit Automation software could greatly improve audit professional to focus on high-level analysis and decision-making rather than doing the mundane works of audit like data extraction and sorting, source documents review and reconciliation.

Audit Automation (AA) is a game changer in both business and in the auditing landscape which assist auditors to conduct more accurate, faster, and effective audits. In short, AA helps to enhance the current audit landscape to a more streamline process in a shorter duration. Audit Automation does have the potential to offer great benefits to auditors in general. But there will be foreseeable challenges like resistance to change, cost of implementation, poor-quality data collected, re-training staffs and new setup of operation procedures.

By the benefits brought upon by AA far outstrip these challenges in the long run and by using best practices in the business organisation the relevant stakeholders can ensure of a smooth transaction process in implementation of AA.

Regarding this, the main aim of this study is to examine audit automation challenges that the auditors in Malaysia may encounter in its implementation. The study had 51 respondents out of the 100-questionnaire distributed. The study is focus on the empirical examination of the automation challenges in Malaysia accounting audit sector.

LITERATURE REVIEW

Audit Automation

Technology development has accelerated over the past few decades and gained significance for accounting and auditing. For the last few years, the use of technology in the audit process has greatly increased as audit firms has more desire and motivation to improve audit efficiency, especially to compete for clients and service them better (Manson,McCartney & Sherer, 2000). With technology, the field of auditing is being automated which provides reliability and accuracy on the audit processes. Automation is not only a strategy being adopted by Big Four audit firms, but by most audit firms to cope with a more competitive environment. The need to lower audit costs and the need to improve quality of audit work signifies the justification for audit firms in investing large portion of their investment in audit automation

(Manson et al, 1997). Technology's ability to handle ever-increasing data volumes can help achieve excellent audit quality and free up auditors to focus primarily on assessing risks and providing companies with strategic ideas (Salijeni et al., 2021)

Audit processes are basically a set of activity which involves tasks such as obtaining evidence, organizing, processing, evaluating, analysing, and presenting data to provide a trustworthy opinion, which is called audit opinion on the financial statements (Omateso, 2012). With the increasing demand and pressure to be efficient in providing appropriate and adequate opinion, it is important for the auditors to embrace technology to remain competitive. Audit firms employs audit automation to maintain not only their competitiveness, but also their profitability. Yet, it is important to understand the challenges that comes with Audit Automation. Previous researchers such as (Child, 1991; Helliwell & Fowler, 1994) has highlighted significant complex implication from audit automation for an organisation.

Digital technologies such as Artificial Intelligence, Blockchain Technologies, Robotic Process Automation and Big Data Analytics allows auditors to provide a better and efficient audit opinion by reducing the level of audit risk. (Vukovic,Tica & Jaksic, 2023). These technologies provide better documentation and allows auditors to make a more strategical decision making yet these technologies do come with its challenges. The purpose of this study is to determine and measure the extend of the challenges faced by auditors with this automation.

Technologies with Audit Automation

In the current area of digitalization, businesses all throughout the world are dealing with massive volumetric transactions in a daily basis. Traditional model of audit could not cope with huge volume of data and the audit process get repetitive. There has been an elevated pressure on external auditors to contribute more efficiently and effectively with their role on governance and control of corporate entities (Omoteso, 2012).

A whitepaper by Chartered Professionals Accountants of Canana, with AICPA, has highlighted that with an evolving audit profession, audit innovations in automation such as data analytics and blockchain; may have a significant impact on the way auditors execute their engagements. The whitepaper also stressed the necessity for auditors to broaden their skills set and competence to meet client’s demand, especially clients who for example, already adopted technologies such as blockchain technologies. With the purpose to maintain a competitive edge in both local and international markets and fulfil the increasing demands of customers, modern organisations need to adopt and integrate digital and advanced technologies.

Not only that, with automation, time required for issuing audit reports is impacted; be getting lesser, with the use of digitalisation in the audit process. (Fotoh & Lorentzon, 2020). Automation in audit does not change the purpose of audit or the audit procedures, it changes the method of implementation and the process to ensure efficiency and reduces human error (Mariia & Viktoriia, 2020). Yet, developing a culture of innovation to embrace technology and automation in audit could be challenging.

Robotic Process Automation

Robotic Process Automation (RPA) is a form of automation technology that uses software

robots to automate business tasks typically performed by humans. Utilising structured-input programs and logic-driven software applications, RPA performs certain digital labour activities at the user interface level (Plattfaut and Borghoff, 2022). Basically, RPA does not mean a physical robot carrying on an activity, but it involves digital bots which can be trained to do various tasks (Zhang, 2019). With RPA, routine tasks are automated, and it clearly reduces human error. Audit processes such as audit confirmations, reconciliations, email generations can be generated using the RPA. For example, structured data can be extracted from documents and calculations can be performed; basic audit documentation and forms can be filled by RPA.

Deloitte conducted a global RPA survey in 2020 and found that nearly 53% of respondents, in 2020 itself has started integrating RPA into audit processes. This technology also allows a full dataset analysis rather than sampling. By automating these processes, auditors can now have more time on providing strategical analysis and valuable insight. The capacity to save time on repetitive tasks, the potential for continuous workdays, speed, resilience, and increased scalability are the main advantages of using RPA in auditing (Vukovic,Tica & Jaksic, 2023).

One of the challenges of RPA is that not all audit processes are RPA friendly, as such in 2023, Ernst and Young Foundation has come up with a framework which suggest that only highly repetitive processes which involves structured data can be automated with RPA. Another survey by PWC, in 2017 estimates that in an audit engagement, 45% of the audit processes can be automated. For example, in procedures such as selecting sample, populating templates, and calculating materiality, automation using RPA is efficient. Procedures such as loading client data into analytics and creating audit paper works can also be automated with RPA (Liu, 2022).

At the same time, auditors need to have specific training, instruction manual and guidance in order to successfully implement RPA into audit process and procedures (Eulerich et al, 2022).

Blockchain Technology

The emergence of blockchain technology and some features, including smart contracts, have significant ramifications for the auditing industry. Blockchain technology is suitable for the auditing profession because of its ability to monitor transactions and system modifications real time while preventing manipulation (Nezhyva & Miniailo, 2020).

For example, the feature of smart contract with blockchain technology, which is a method to automate the contracting process and enable monitoring of contractual promises with minimal human intervention. The use of smart contracts by auditors improves audit efficiency by reducing human error. Yet, the challenge here would be when all the contracts' terms need to be translated to logic.

Blockchain is merely a distributed ledger which contains the relevant details for every transaction that has ever been processed. With clients implementing blockchain technologies, auditors must ensure they understand the method to obtain sufficient audit evidence with blockchain ledgers. For example, auditors usually receive information from clients in various electronic forms and each audit task begins with different schedules and plan by the audit team. With blockchain, auditors can have real time data access provided auditors have the skills and competence to understand the technology. This also allows the auditors to signal on the red flags whenever they notice an unusual transactions real time.

Artificial Intelligence

Organisation investment in Artificial Intelligence has skyrocketed in recent years (Furman & Seamans, 2019). Artificial intelligence possesses the capability to transform the function of external audit given its ability to automate repetitive tasks; as AI algorithms recognises pattern which allows repetitive processes such as data entry to be automated. This processes traditionally are done manually which consumes most of auditor's time. Earlier predicted by researcher such as Bell, Knechel, Payme and Willigham (1998), technologies such as EDI (Electronic Data Exchange), EFT (Electronic Fund Transfer), and Image Processing are replacing traditional audit processes. Auditors investing in AI evidently shows improvement in terms of audit quality while they also managed to reduce their audit fees for their clients (Fedyk,Hodson, Khimich & Fedyk, 2022); and their research has proved that audit firms investing in AI are able to measurably lower the incidence of restatements, material restatements, restatements related to accruals and revenue recognition, and restatement-related SEC investigations.

Big Data Analytics

Researchers such as Brown et al, 2020 and Perols et al, 2017; has pointed out that data analytics can improve predictions in audit. Data analytics is "*the science and art of discovering and analysing patterns, identifying anomalies, and extracting other useful information in data underlying or related to the subject matter of an audit through analysis, modelling, and visualization for the purpose of planning or performing the audit*" (AICPA, 2017). When firm employs data analytics in multi-level audit processes, such as powerful data analytical tools, audit effectiveness will directly show an increase in terms of quality (Appelbaum et al, 2017).

In an interview of 17 audit partners, researcher Walker and Brown-Liburd (2019) found that competition, client, and regulatory agencies impact their decision to explore and employ data analytics into their audit processes. Yet, it is crucial to note that growing reliance on analytical tools in audit processes does lead researchers to explore further into its challenges. Researchers such as Salijeni et al, 2019 does expressed some doubts on the use of data analytics and whether it will have any significant impact on audit. The challenges arises when some auditors push data analytics when it comes to remain competitive (Austin et al, 2021). At the same time, with paradigm shift from traditional audit, data analysis requires auditors to obtain data samples for digital audit, which may lead to discrepancies between data from client and auditors' expectations (Fotoh & Lorentzon, 2020).

Data analytics and artificial intelligence together can enhance audits by resulting in creation of knowledge base which can be used across audit procedures from audit engagement (Earley, 2015). The challenge in using data analytics is that the success of data analytics tools depends on few factors such as clients' business environment, business size and the extend of technologies they adopt (Dagiliene & Kloviene, 2019).

DATA AND METHODOLOGY

Population and Sample

This study aims to examine the challenges associated with audit automation that auditors in Malaysia may encounter. To fulfil the objectives of the research, the study focuses on a population of auditors based in Malaysia. Researchers often rely on a sample of the

population due to practical considerations such as time limitations, cost-efficiency, and accessibility constraints (Veel A.J, 2017). A review of prior research in the auditing field reveals that sample sizes typically range from 50 to 150 auditors (Karim et al, 2022) (Ismail A.H et all, 2020) and (Zhang C, 2019). Consequently, this study selected a sample of 80 auditors, who were invited to participate through an online survey. Of these, 51 provided complete and valid responses, yielding a response rate of 63.75 percent. Thus, the final sample for this study consists of 51 respondents.

Data Collection

The current study employed a quantitative questionnaire as the instrument to collect data. Questionnaires can be either quantitative or qualitative. Quantitative questionnaires involve expressing answers to the questions in numeric form, such as coding responses or using a rating scale (e.g., 1 to 5). In contrast, qualitative questionnaires allow respondents to write their answers in their own words. The quantitative approach, however, uses questionnaires as data collection tools and seeks to provide statistical evidence to address the research questions (Lewin C, 2005).

In this context, the current study used a quantitative questionnaire to empirically and statistically investigate the challenges related to audit automation that auditors in Malaysia may face. The questionnaire comprises a total of 12 questions, divided into three main sections. The first section covers demographic information, including 5 questions about gender, age, highest level of education, years of auditing experience, and type of audit firm.

The second section consists of 5 questions aimed at examining the challenges auditors in Malaysia face regarding audit automation. These questions are measured on a five-point Likert scale, ranging from 1 (not challenging or not adoptable) to 5 (very challenging or highly adoptable). Finally, the third section contains 2 questions, which investigate the specific skills auditors need and the new technologies they are incorporating into their current audit work. The responses to these two questions were coded for subsequent analysis.

RESULT AND DISCUSSION

Reliability Test

To ensure the robustness of the findings, Cronbach's alpha coefficient was computed, assessing the internal consistency of the measurement scale, which comprised five items targeting audit automation challenges. The alpha coefficient stood at a solid 0.804, indicating a high level of internal consistency and reliability across the board (Bujang M A, et all, 2018)

Demographic Insights

Table 1 presents a panoramic view of the demographic landscape of the surveyed auditors, revealing intriguing patterns and shedding light on the composition of the respondents. Gender-wise, the sample is dominated by females (60.78%), overshadowing their male counterparts (39.22%), perhaps reflecting broader industry trends or simply a higher response rate among female auditors. Age-wise, the majority (56.86%) falls within the youthful 25-34 range, followed by 17.65% aged between 35-44, and a mere 1.96% aged 55 and above.

Educationally, nearly half (49.02%) of the respondents possess a bachelor's degree, with 27.45% holding a masters. A notable 9.80% carry professional certifications like CPA or ACCA, indicating a strong presence of highly accredited professionals. Experience-wise, most respondents have clocked between 1-6 years in the audit world, hinting at a cohort predominantly composed of early- to mid-career professionals. Firm-wise, 39.22% are employed by mid-tier firms, 31.37% by small firms, and 23.53% by Big Four firms, while a smaller 5.88% are sole practitioners. This distribution suggests that the study captures a wide array of perspectives from various firm environments.

Table 1 – Demographic characteristics

Demographic characteristic	Sub-characteristic	Frequency	Percent
Gender	Male	20	39.22
	Female	31	60.78
Age	Under 25	7	13.73
	25-34	29	56.86
	35-44	9	17.65
	45-54	5	9.80
	55 and above	1	1.96
Highest Level of Education	Diploma	3	5.88
	Bachelor's Degree	25	49.02
	Master's Degree	14	27.45
	PhD	4	7.84
	Professional Certification (e.g., CPA, ACCA)	5	9.80
Years of Experience in Auditing	Less than 1 year	12	23.53
	1-3 years	13	25.49
	4-6 years	12	23.53
	7-10 years	9	17.65
	More than 10 years	5	9
	Big Four	12	2
	Mid-tier	20	3
	Small Firm	16	3
	Sole Practitioner	3	5

Results of Audit Automation Challenges

Table 2 shows the descriptive statistics used to examine the potential challenges linked to audit automation among Malaysian auditors. Responses to five pivotal questions were categorized using defined agreement levels: scores from 1 to 1.8 indicate "strongly not challenging or not adoptable," scores between 1.81 and 2.6 denote "not challenging or not adoptable," scores spanning 2.61 to 3.4 fall into a "neutral" zone, scores between 3.41 and 4.2 suggest "challenging or adoptable," and scores from 4.21 to 5 reflect "strongly challenging or highly adoptable." These statistics provide a lens through which to view respondents' attitudes, contextualized by the literature on technological hurdles and automation complexities.

Respondents were asked to rate the challenge of managing data volume and complexity with

automated tools, yielding a mean score of 3.82—squarely within the "challenging" range. This finding echoes the concerns raised by Salijeni et al. (2021), which illustrate how burgeoning data complexity can stymie even well-designed automation tools. Despite these tools enhancing accuracy and efficiency, auditors still wrestle with unwieldy data flows. Keeping up with the relentless pace of technological evolution scored a mean of 3.94, indicating that auditors find it "challenging" to frequently update their skills. Omoteso (2012) highlights similar pressures, noting that auditors must continually hone their abilities as automation technology, including blockchain, RPA, and AI, becomes more entrenched in audit practices. This dynamic environment necessitates substantial investments in learning and adaptation (Chartered Professional Accountants of Canada, 2021).

A mean score of 3.51 places the adaptability of current tools to new technology and client environments in the "challenging" range. Vukovic et al. (2023) underscores that while tools like RPA boost efficiency, their capacity to adjust to technological shifts and environmental changes remains constrained, especially when designed for specific, repetitive tasks. When asked about the difficulty of integrating new technologies into the audit process, respondents assigned a mean score of 3.92, firmly within the "challenging" range. Mariia and Viktoriia (2020) note that integrating technologies like AI and data analytics into traditional frameworks is no small feat—it requires not only technological preparedness but also substantial organizational backing and training resources.

The final question tackled regulatory and compliance issues, yielding a mean score of 3.82, again within the "challenging" bracket. Fotoh & Lorentzon (2020) explain that regulatory frameworks often struggle to keep pace with technological advancements, resulting in a convoluted landscape that auditors must navigate while adopting new tools.

Table 2 – results of audit automation challenges "descriptive statistics "

Questions	N	Minimum	Maximum	Mean	Std. Deviation
On a scale of 1 to 5, how challenging do you find managing the volume and complexity of data with automated audit tools?	51	2	5	3.824	.9318
On a scale of 1 to 5, how challenging do find the need of frequently updating your skills and competencies to keep up with new audit automation technologies?	51	2	5	3.941	.8582
How adaptable do you find your current audit automation tools to changes in technology and client environments?	51	1	5	3.51	.987
On a scale of 1 to 5, how challenging do you find integrating new technologies into your audit processes?	51	1	5	3.92	1.017
On a scale of 1 to 5, how challenging do you find regulatory and compliance issues related to audit automation?	51	2	5	3.82	.910
Valid N (listwise)	51				

Results of Skills Lacking and Technology Adoption

Understanding the precise skill gaps and the extent of technology adoption is paramount. Table 3 revealed that a staggering 74.51% of respondents struggle with data analytics, aligning with findings from Salijeni et al. (2021). Similarly, 66.67% reported a lack of

proficiency in RPA, as pointed out by Vukovic et al. (2023), while 54.90% cited IT security as a challenge, a concern echoed in Zhang's (2019) research. Skills gaps were also noted in blockchain (52.94%) and AI (50.98%).

Despite these gaps, many auditors are proactively embracing new technologies, with 66.67% adopting big data analytics, 52.94% integrating RPA, and 50.98% employing AI technologies in their processes.

Table 3 – Results of Skills Lacking and Technology Adoption

Questions	Selections	Frequency	Percent
What specific skills do you find most lacking when dealing with current automated audit tools? (Select all that apply)	Data analytics	38	74.51
	Artificial Intelligence	26	50.98
	Blockchain Technology	27	52.94
	Robotic Process Automation	34	66.67
	IT Security	28	54.90
Which new technologies have you integrated into your audit processes? (Select all that apply)	Big Data Analytics	34	66.67
	Artificial Intelligence	26	50.98
	Blockchain Technology	25	49.02
	Robotic Process Automation	27	52.94
	None	6	11.76

IMPLICATION OF THE STUDY

Based on this study, the authors identified that it is crucial for audit firms to relook into their talent management strategies as with audit automation, auditors are required to engage into higher level analytical work. To do that, strong analytical and IT skills are essential and based on our study, most auditors still find it "challenging" to frequently update their skills.

At the same time, it is pivotal for auditors to recognize the importance of upskilling, as we see, most auditors are lacking in data analytics skills based on our survey. These skills are the foundation for higher level decision making required from auditors. As such, despite giving equal importance to traditional audit skills as a base, auditors needs to add value to their skills in terms of sustaining in technology driven audit environment.

These study can be a lead to regulatory bodies such as Malaysian Institute of Accountants (MIA) where they can revisit the auditing standards to accounts on the widespread of automation. At the same instances, universities and colleges preparing the next generation of auditors needs to incorporate the element of automation in sylabus. Incorporating automation modules on auditing definitely requires significant investment in technology and training. This is where the Government and Private organizations comes in to allocate sufficient funds to it.

With an increased dependence on automation, it is also crucial to boaster cyber security. 50% of the responded does highlight on IT security is a challenge for the adoption of audit automation. Data breaches could be addressed with a stronger audit trails and auditors needs to again understand the fundamentals of auditing to close the gaps in trails. Audit firms can also focus on encryption and data protection policies to adopt audit automation efficiently.

Increased reliance on automation indicates a shift in auditors job expectation, which based on our survey, evidently point to strategic decision making. As such, skills required to evolve auditors such as analytical skills needs to be boosted as auditors stills are facing challenges to cope with technology behind making a decision.

CONCLUSION

This study aims to examine the challenges associated with audit automation that auditors in Malaysia may encounter. In this regard, the study examined various facets of automation, including skill requirements, technology adoption, and regulatory challenges, revealing a landscape marked by a mix of adoption and hesitation. Auditors generally perceive automation as "challenging," particularly in terms of data management, skill upgrading, tool adaptability, and compliance. Addressing these challenges requires concerted efforts in training, resource allocation, and organizational support.

REFERENCES

Agostini, M. (2024). Transforming corporate governance: Exploring tokenization's impact on transparency and ownership — A research agenda. Risk Governance and Control: Financial Markets and Institutions, 14(3), 47-56. https://doi.org/10.22495/rgcv14i3p5

Audit's digital revolution: How technology is reshaping the industry. (2024, March 12). Wolters Kluwer – Combining Domain Expertise With Advanced Technology | Wolters Kluwer. https://www.wolterskluwer.com/en/expert-insights/audits-digital-revolution-how-technology-is-reshaping- the-industry

Bujang, M. A., Omar, E. D., & Baharum, N. A. (2018). A review on sample size determination for Cronbach's alpha test: a simple guide for researchers. The Malaysian journal of medical sciences: MJMS, 25(6), 85.

CFI Team. (2023, March 14). Top accounting scandals. Corporate Finance Institute. https://corporatefinanceinstitute.com/resources/accounting/top-accounting-scandals/

Chatterji, R., Basu, P. P., Chatterjee, J., & Basu, S. (2023). Research strategies: Quantitative and qualitative. Conjectures and Evidence, 3-21. https://doi.org/10.4324/9781003407843-2

Cooper, R. B., & Zmud, R. W. (2021). Information Technology Implementation Research: A Technological Diffusion Approach. Management Science, 36(2), 123–139.

Deloitte CFO survey. (2024). Risk, Fraud & Compliance, (1). https://doi.org/10.37307/j.1867-8394.2024.01.05

EY Academic Resource Center. (2023). Innovation Mindset. Robotic Process Automation.

Fossung, M. F., Fotoh, L. E., & Lorentzon, J. (2020). Determinants of audit expectation gap: The case of Cameroon. Accounting Research Journal, 33(4/5), 561-576. https://doi.org/10.1108/arj-12-2019-0241

Furman, J., & Seamans, R. (2019). AI and the economy. Innovation Policy and the Economy, 19, 161-191. https://doi.org/10.1086/699936

Ismail, A. H., Merejok, N. B. M., Dangi, M. R. M., & Saad, S. (2019). Does Audit Quality Matters in Malaysian Public Sector Auditing? International Journal of Financial Research, 10(3), 203. https://doi.org/10.5430/ijfr.v10n3p203

Karim, A., Syamsuddin, I., Jumarding, A., & Amrullah, A. (2022). The Effect of Gender Independence and Leadership Style on Audit Quality in Makassar Public Accounting Offices. International Journal of Social Science Research and Review, 5(7), 114–126. https://doi.org/10.47814/ijssrr.v5i7.341

Lewin, C. (2005). "Elementary quantitative methods." Research methods in the social sciences: 215-225

Manson, S., McCartney, S., & Sherer, M. (2001). Audit automation as control within audit firms. Accounting, Auditing & Accountability Journal, 14(1), 109-130. https://doi.org/10.1108/09513570110381097

Moll, J., & Yigitbasioglu, O. (2019). The role of internet-related technologies in shaping the work of accountants: new directions for accounting research. The British Accounting Review, 51(6), 100833. https://doi.org/10.1016/j.bar.2019.04.002

Nazarova, K., Nezhyva, M., Lositska, T., Miniailo, V., & Novikova, N. (2021). Forensic audit as an imperative of economic security and development of the company in the conditions of global transformations. Financial and credit activity problems of theory and practice, 4(35), 99-106. https://doi.org/10.18371/fcaptp.v4i35.221808

Silva, R., Inácio, H., & Marques, R. P. (2021). Effective and potential implications of blockchain technology for auditing. Advances in Intelligent Systems and Computing, 435-451. https://doi.org/10.1007/978-3-030- 72654-6_42

Shaoyu Liu, S. L. (2022). Robotic process automation (RPA) in auditing: A commentary. International Journal of Computer Auditing, 4(1), 022-027. https://doi.org/10.53106/256299802022120401003

Taulli, T. (2020). The robotic process automation handbook: A guide to implementing RPA systems. Apress. Veal, A. J., Jenkins, J., Henderson, K. A., McDonnell, I., & Veal, A. J. (2001). Book Reviews. Annals of Leisure Research, 4(1), 95–106. https://doi.org/10.1080/11745398.2001.10600893

Walker, K., Barr-Pulliam, D., & Brown-Liburd, H. L. (2022). Embracing a paradoxical environment to promote technological advancements in auditing: Perspectives from auditors in the Field. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4286205

SUB-THEME 2
DIGITAL LEARNING AND SOCIETY

SOCIETY 5.0 AND DIGITAL TRANSFORMATION IN LIFE LONG LEARNING: A QUALITATIVE STUDY

Dr. P. Sivakumar[A]

ABSTRACT

The dynamics of Society 5.0 and Digital Transformation paved the way for a striking innovation in Lifelong Learning. Society 5.0 is characterised by technological development and transformation which leads to change in every walk of human life, including the learning environment. The learning environment in Lifelong Learning, which is based on the personal and occupational needs, interests, and learning requirements of individuals, is also undergoing a rapid change in its landscape. The main objective of the study is to find out the impact of Society 5.0 and digital transformation on lifelong learning. This study is a qualitative approach based on the technique of Focus Group Discussion (FGD). The sample for the study represents various groups of stakeholders, including professors, Administrators from Higher Educational Institutions, Adult Learners, Alumni and Technologists. The data were collected based on the responses to open-ended questions presented by the moderator. The content analysis method was applied to the data analysis. It is concluded that Society 5.0 and digital transformation make things easier in every walk of life and ensure diversity in learning. The learning environment is composed of Artificial Intelligence, Interactive Multimedia, and the Internet of Things. The learning approach is focused towards student-centred and teacher-directed. The learning method emphasized blended learning and digital learning. Hence, it is recommended that these dynamic changes in Society 5.0 and in digital transformation should carefully be accommodated in the Life-Long Learning process gradually to fulfil the needs of the Life-Long Learners.

Keywords: *Society 5.0, Digital Transformation, Life-Long Learning, Focus Group Discussion (FGD)*

INTRODUCTION

Digital transformation and Society 5.0 are two revolutionary ideas that are progressively influencing the future in the quickly changing global society. Digital transformation is the process of using digital technology to improve employee performance, organizational agility, and organizational efficiency (Henriette et al., 2015). Society 5.0 can be defined as a smart community where the physical world and cyberspace are very integrated (Salgues, 2018).

Digital transformation extends beyond mechanical structures, and to successfully adapt to digital processes, it is important to take into account that it has social effects with information sharing and a collaborative approach (Gözüküçük, 2020; Stolterman & Fors, 2004).

[A] *Senior Professor & Head, Department of Education (CDOE), Centre for Distance and Online Education, Alagappa University, Karaikudi 630003, Tamil Nadu, India. Email: psksiva2002@gmail.com; sivakumarp@alagappauniversity.ac.in Website: www.sivakumareducation.com DOI: https://orcid.org/0000-0002-0245-6947*

Puncreobutr (2016) mentioned that people's work and social lives have changed during the transformation process. Humanism is the main focus of Society 5.0, which places a high priority on the advancement of scientific and technological discoveries that primarily serve the economic sector. Salgues (2018) mentioned the characteristic features of Society 5.0; i) It uses information and communication technology fully, ii) It is community-centerd, iii) people participation, iv) It has common values: sustainability, inclusive, effective, and intelligence power, and v) development of economic disruption. Ultimately, Society 5.0 aspires to harmonize the relationship between technology and humanity, ensuring that advancements contribute positively to both individual well-being and the broader social fabric.

Invariably, Technological transformation triggered many impacts on society. It is necessary to study the impact of these changes and issues in every sphere of societal development. To address societal issues and improve well-being, the Japanese government's "society 5.0" concept imagines a "super-smart society" that incorporates cutting-edge technologies like robotics, big data, the Internet of Things (IoT), and artificial intelligence (AI) into every facet of daily life. This vision goes beyond Industry 4.0's technological emphasis by focusing on a human-centred strategy that uses innovation to improve people's lives, heal societal divisions, and build sustainable futures (Fukuda, 2020).

Lifelong learning faces both tremendous potential changes and problems in the digital age, especially when it comes to giving people the skills and competencies they need to prosper in a knowledge-based, technologically advanced society. As technology keeps changing the way people work, develop economically, and interact with others, lifelong learning becomes crucial to maintain ongoing development on both personal and professional levels. The main objective of the present study is to find out the impact of Society 5.0 and digital transformation on lifelong learning. This study is a qualitative approach based on the technique of Focus Group Discussion (FGD).

LITERATURE REVIEW

The idea of a "society 5.0" incorporates technology into society to strike a balance between societal issues and economic advancement. It is also known as the Super Smart Society. Society 5.0 is based on the realization of technological integration by creating harmony and balance between human and technology (Yaraş et al. 2022). It is mentioned that the social needs of Society 5.0 in different fields are met with advanced technology products such as artificial intelligence (Saracel et al. 2017). In addition, it is also prioritized to increase the quality of life by increasing the welfare and happiness levels of societies with technology-human integration (Serpa & Ferreira, 2018). Society 5.0 will feature an iterative cycle in which data are gathered, analyzed, and then converted into meaningful information, which is then applied in the real world; moreover, this cycle operates at a society-wide level (Deguchi et al. 2020). Society 5.0 attempts to integrate technology with society, prevent negative impacts, and create effective societies.

Akin et al. (2021) evaluated the concept of Society 5.0 and discussed the integration of Society 5.0 technologies into the daily lives of people and society. The authors analysed previous studies on Society 5.0 and found that researchers in Japan, Turkey, and Indonesia conducted the most studies in this field. Abdullah Zübeyr Akman and Meral Erdirençelebi (2024) carried out a comprehensive bibliometric analysis that sheds light on the evolving concepts of Society 5.0 and Industry 5.0, emphasizing their significance in the context of digital transformation. The study highlights key themes such as artificial intelligence and sustainability, while also identifying influential authors and countries contributing to the

discourse. Furthermore, the authors advocate for future research to expand beyond English-language publications, particularly in nations like Japan, China, and India, to enrich the global understanding of these transformative concepts.

Mourtzis (2023) explored the future of the human-machine interface in Society 5.0. The study presents a comprehensive exploration of the evolving relationship between humans and machines, particularly in the context of Industry 4.0 and the emerging concept of Society 5.0. It emphasizes the critical role of Artificial Intelligence (AI) in enhancing human capabilities and productivity, while also addressing the challenges and ethical considerations that arise from this integration. The authors effectively highlight the necessity for a balanced approach that fosters collaboration between human intelligence and machine efficiency, advocating for the development of frameworks that prioritize human-centric design. By examining the implications of these advancements on the workforce, the study underscores the importance of adapting skill sets to meet the demands of a technology-driven future, ultimately positioning the human-machine partnership as a cornerstone for innovation and societal progress.

Nadoleanu et al. (2022) explored on Sociology and Anthropology of the Digital Sphere as Sustainability Knowledge Resources of Society 5.0. It offers a compelling exploration of the intricate relationship between technology and social transformation, particularly in the context of the digital age. The authors effectively argue that our identities and social interactions are continuously reshaped by digital technologies, highlighting the shift from traditional face-to-face communication to increasingly ephemeral digital engagements. They draw on historical and sociological perspectives to illustrate how technological advancements have not only influenced social structures but also redefined human identity and interaction. The discussion on generational differences in media consumption, particularly the rapid decline in attention spans and the rise of platforms like TikTok, underscores the urgency of understanding these dynamics for fostering a sustainable society. They have provided valuable insights into the challenges and opportunities presented by the digital sphere, making a significant contribution to the discourse on sustainability in the context of Society 5.0.

Carayannis and Morawska-Jancelewicz (2022) suggested that how can implement the principles of Society 5.0. It is suggested that universities must transform into dynamic hubs of innovation and sustainability. This involves creating supportive structures that foster interdisciplinary collaboration, integrating sustainability into their core missions, and actively engaging with stakeholders from various sectors. By leveraging digital technologies to enhance learning experiences and promoting a culture of lifelong learning, universities can empower students to navigate the complexities of the future. Ultimately, by embracing these principles, universities can become catalysts for social progress, driving meaningful change and contributing to a more inclusive and sustainable society.

The study carried out by Yaraş et al. (2022) identified both the advantages and disadvantages of Society 5.0 for its methods of operation. These findings have led to the conclusion that shifting business conditions brought about by technological advancements in Society 5.0 can have a negative impact on both favourably and in terms of persons. The reduction of time and money spent travelling to work, along with flexible working arrangements, were articulated as a top priority. Among the most important effects of technology were motivation and the blending of personal and professional lives as well as business integration.

Kraus et al. (2021) conducted a study on digital transformation that provided a comprehensive overview of digital transformation (DT) research, highlighting its significance across business, technological, and societal dimensions. The study emphasized the critical need for organizations to embrace digital transformation to remain competitive in an evolving landscape, while also acknowledging the challenges and opportunities that come with it. Pereira

et al. (2020) presented a compelling vision of Society 5.0, emphasizing the transformative role of intelligent systems in enhancing human life and addressing complex societal challenges. By leveraging advanced technologies from Industry 4.0, Society 5.0 aims to create a "super-intelligent society" where human beings are at the centre of innovation and technological advancement.

Thus, many research works have been carried out in digital transformation and Society 5.0 to get conceptual clarity and contextual reality. Overall, the studies effectively articulated the potential of intelligent systems to drive positive change, making a strong case for their essential role in shaping a future that prioritizes human well-being and societal progress. It is inferred that this paradigm shift not only focuses on improving living standards but also seeks to ensure safety, security, and comfort for individuals. The integration of cyber-physical systems (CPS) is highlighted as a means to connect diverse values and sectors, fostering a sustainable society that promotes economic growth and equitable wealth distribution.

DATA AND METHODOLOGY

This study adopted a qualitative methodology, gathering data through the Focus Group Discussion (FGD) technique. A focus group is a form of in-depth interview conducted with a group, characterized by specific parameters related to the proposal, size, composition, and interviewing methods. Krueger (1994) defined focus groups as discussions planned to gather data on a specific topic from participants in a friendly non-threatening environment, strengthening the atmosphere of the discussion as a catalyst for data collection. Morgan (1996) defined focus groups as a research technique that collects data through group interaction on a topic determined by the researcher, stressing the relevance of group interaction and focused discussion (Albanesi, C. 2014). The sample for the study represents various groups of stakeholders including Professors, Administrators from Higher Educational Institutions, Adult Learners, Alumni and Technologists. The data were collected based on the responses to open-ended questions presented by the moderator.

Research questions

The following research questions are framed:

- How do digital transformations and Society 5.0 influence lifelong learning?
- What kinds of learning environments exist in the age of Society 5.0 and digital transformations?
- Which learning approach is indispensable for lifelong learning in Society 5.0?
- In Society 5.0, which learning methods are best suited for lifelong learning?

Content analysis

The content analysis method was applied to the data analysis. Content analysis enables a systematic coding of data by organising the information into categories to discover patterns undetectable by merely listening to the tapes or reading the transcripts (Yin, 1989). A single focus group is selected from different stakeholders, including Professors, Administrators from Higher Educational Institutions, Adult Learners, Alumni and Technologists. The key feature of single focus group is the interactive discussion of a topic by a collection of all participants and a team of facilitators as one group in one place. This is the most common and classical type of focus group discussion (Morgan, 1996). It has been widely used by both researchers and

practitioners across different disciplines (Lunt & Livingstone, 1996; Morgan, 1996; Wilkinson, 1998). The sample size consists of fifteen; three from each stakeholder, viz Professors, Administrators from Higher Educational Institutions, Adult Learners, Alumni and Technologists. The discussion lasts two hours per day with a break of ten minutes for seven days. Semi-structured questions are framed based on the experts' opinions. The moderator as a neutral person presented the questions one by one and equal importance was given to all members. The following steps are involved in the Content analysis; Step i) Preparation of Transcript, Step ii) Coding Step, iii) Developing Categories, Step iv) Identifying Themes, and Step v) Interpretation and Reporting Findings.

Ethical Considerations

The study followed ethical principles, including informed consent, confidentiality, and voluntary participation. Participants received complete information about the study, its objectives, and its academic nature. All data were anonymized to protect the participants' identities.

RESULTS AND DISCUSSIONS

The following are the findings of the study:

- Digital transformation and Society 5.0 can make lifelong learning more accessible to individuals with disabilities or those in remote areas. It enables personalized learning experiences tailored to individual needs and preferences.
- Digital transformation is driving demand for new skills, such as digital literacy, critical thinking, and problem-solving. At the same time, issues such as privacy, data security, and the digital divide may arise as technology becomes more integrated into lifelong learning.
- The learning environment in Society 5.0 is composed of Artificial Intelligence, Interactive Multimedia and the Internet of Things.
- The learning approach in Society 5.0 is focused towards student-centred and teacher-directed.
- The learning methods emphasized are blended learning and digital learning.

The results of the study could influence practices and policy in lifelong learning. Digital transformation can make lifelong learning more accessible to individuals and hence, policymakers may need to make investments in digital infrastructure and techno -androgogical skills. The new curricula and evaluation techniques should have been aligned following this technological transformation. Using technology, learning can be customized to meet the requirements and preferences of each individual which leads to personalized learning that is the product of self-organization. Spector (2020) emphasised that in this century, big data and learning analytics are poised to transform personalized learning once again. Learning has been characterized as a stable and persistent change in accordance with technological transformation. FitzGerald et al. (2018) pointed out the personalization of learning is now a recurring trend across government agencies, popular media, conferences, research papers, and technological innovations. It seems that technology-enhanced personalized learning models are gaining more attention in Society 5.0.

Automation, digitization, and the quick development of technology are changing the nature of society. Significant changes are occurring in the society following the developments in the digital age. People need to learn new skills like digital literacy, critical thinking, and problem-solving to thrive in this dynamic Society 5.0. Digital literacy has been defined as the competencies and skills required for navigating a fragmented and complex information ecosystem (Eshet, 2004). Tinmaz et al. (2022) mentioned that a 'Digital Literacy Framework' was designed by Eshet-Alkalai (2012), comprising six categories: (a) photo-visual thinking (understanding and using visual information), (b) real-time thinking (simultaneously processing a variety of stimuli), (c) information thinking (evaluating and combining information from multiple digital sources), (d) branching thinking (navigating in non-linear hypermedia environments), (e) reproduction thinking (creating outcomes using technological tools by designing new content or remixing existing digital content), and (f) social-emotional thinking (understanding and applying cyberspace rules). Hence Society 5.0 should take care of various categories of digital literacy.

In a time of accelerating technological transformation in Society 5.0, critical thinking and problem-solving abilities are the most important skills. They help people make wise judgments, deal with difficult issues, and adjust to new difficulties. In the workplace, creativity, problem-solving, and productive teamwork all depend on critical thinking. These skills involve analyzing complex situations, evaluating different perspectives, and generating innovative solutions. Thinking critically and adapting to new challenges is essential in a rapidly changing work environment.

Considering another side of digital transformation, issues such as privacy, data security, and the digital divide may arise as technology becomes more integrated into lifelong learning. Security in the digital world primarily refers to preventing unwanted access to data, frequently involving defence against hackers or cybercriminals. Security is the process of keeping personal information safe, while privacy is the ability to control it. Both data safety and privacy elements are equally crucial in Society 5.0 and should be well taken care of.

The study confirmed that the Internet of Things, interactive multimedia, and artificial intelligence constitute the learning environment of Society 5.0. Shahidan (2021) found that engineering, artificial intelligence (AI), and the Internet of Things (IoT) as dominant fields, signifying a heavy reliance on technology. Moreover, the study highlighted the connection between Society 5.0 and the Sustainable Development Goals (SDGs), suggesting that both are interlinked in terms of themes and objectives, particularly in promoting sustainable and human-centred development. This underscores the potential of Society 5.0 to address global challenges, further strengthening its relevance across multiple sectors and SDGs.

In Society 5.0, the emphasis should be on teacher-directed and student-centered learning. The goal of student-centred learning is to help students become more autonomous and independent by giving them control over their learning path by teaching them the skills and theoretical underpinnings necessary to meet the performance requirements. Hence, more learner-centric strategies, methods, and models should be evolved to cater to the needs of learners in Society 5.0. The stakeholders should encourage research studies to bring out changes in accordance with the changing scenarios in these areas. The study also made clear that the learning methods for lifelong learning in Society 5.0 are digital and blended learning. It is witnessed by the digitalisation of all information and human interaction activities by technological advancements in this era of Society 5.0. The Government, NGOs and the general public with digital literacy should take part in digitalisation and blended learning. By using different learning platforms, and artificial intelligence-powered technologies to create flexible, accessible, learner-centric environments, the digital transformation offers new ways to accomplish the objectives of lifelong learning.

CONCLUSION

Society 5.0 and digital transformation together generate environments where learners are empowered by intelligent technology that adapts to their own needs and opens up new possibilities for lifelong learning strategies. Society 5.0 aims to build a 'super smart society' where people, including vulnerable groups, can flourish in secure and nurturing settings by fusing cutting-edge technology with societal demands. In addition to tackling urgent societal issues including environmental sustainability and population ageing, it encourages cooperation between different industries to boost productivity and innovation. Digital revolution is driving the need for new skills including problem-solving, critical thinking, and digital literacy. Issues like data security, privacy, and the digital divide may arise when technology is used in lifelong learning more and more.

It is indispensable to understand the impact of digital transformation and Society 5.0 to take care of the quality of human resources. The main element of initiatives to improve the quality of human resources is lifelong learning, and hence all the stakeholders should be well-prepared based on the needs of Society 5.0 and digital transformations.

REFERENCES

Akin, E.M. Akyol, O. Dalkilic.(2021) An evaluation of the concept of society 5.0 in the lightof academic publications, Ataturk Univ. J. Econ. Adm. Sci. 35 (2) (2021) 577–593.

Akman, A. Z., & Erdirençelebi, M. (2024). A human-centered digital transformation: A bibliometric analysis of society 5.0 and industry 5.0. *Istanbul Management Journal*, (96), 1-16.

Albanesi, C. (2014). Focus Groups. In: Michalos, A.C. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_1066

Carayannis, E. G., & Morawska-Jancelewicz, J. (2022). The futures of Europe: Society 5.0 and Industry 5.0 as driving forces of future universities. *Journal of the Knowledge Economy*, *13*(4), 3445-3471.

Carayannis, E. G., Draper, J., & Bhaneja, B. (2021). Towards fusion energy in the Industry 5.0 and Society 5.0 context: Call for a global commission for urgent action on fusion energy. *Journal of the Knowledge Economy*, *12*(4), 1891-1904.

Deguchi, A. *et al.* (2020). What Is Society 5.0?. In: Society 5.0. Springer, Singapore. https://doi.org/10.1007/978-981-15-2989-4_1

Eshet, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia*, *13*(1), 93–106, https://www.learntechlib.org/primary/p/4793/

Ferreira, C. M., & Serpa, S. (2018). Society 5.0 and social development. *Management and Organizational Studies*, *5*(4), 26-31.

Fitz Gerald, E., Kucirkova, N., Jones, A., Cross, S., Ferguson, R., Herodotou, C., … Scanlon, E. (2018). Dimensions of personalisation in technology-enhanced learning: A framework and implications for design. *British Journal of Educational Technology*, *49*(1), 165–181. https://doi.org/10.1111/bjet.12534.

Harun, E. R., Turan, S., & Kaymakci, S. (2021). Toplum 5.0 Sürecinin Gelişimi Ve Eğitime Etkisinin Değerlendirilmesi. Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, (39), 27–66. http://dspace.adiyaman.edu.tr:8080/xmlui/handle/20.500.12414/2347; https://doi.org/10.14520/adyusbd.993699.

Henriette, E., Feki, M., & Boughzala, I. (2015, December 25). The Shape of Digital Transformation: A Systematic Literature Review. MCIS Proceedings. 10. https://aisel.aisnet.org/mcis2015/10.

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. *Sage Open*, *11*(3), 21582440211047576.

Krueger, R. A. (1994). *Focus group. A practical guide for applied research* (2nd ed.). London: Sage.

Lunt, P., & Livingstone, S. (1996). Focus groups in communication and media research. *Journal of Communication*, 42, 78–87.

Morgan, D. L. (1996). Focus Groups. *Annual Review of Sociology*, 22, 129–152.

Mourtzis, D., Angelopoulos, J., & Panopoulos, N. (2023). The future of the human–machine interface (HMI) in society 5.0. *Future Internet*, *15*(5), 162.

Nadoleanu, G., Staiculescu, A. R., & Bran, E. (2022). The multifaceted challenges of the digital transformation: Creating a sustainable society. *Postmodern Openings*, *13* (1 Sup1), 300 - 316.

Pereira, A. G., Lima, T. M., & Santos, F. C. (2020). Industry 4.0 and Society 5.0: opportunities and threats. *International Journal of Recent Technology and Engineering*, *8*(5), 3305 - 3308.

Puncreobutr, V. (2016). Education 4.0: New challenge of learning. Journal of Humanities and Social Sciences, 9(5), 92-97.

Salgues, B. (2018). *Society 5.0 Industry of the Future, Technologies, Methods and Tools.* London: ISTE Ltd.

Saracel, N., & Aksoy, İ. (2020). Society 5.0: Super Smart Society. Social Sciences Research Journal, 9(2), 26-34.

Serpa, S., & Ferreira, C. M. (2018). Society 5.0: Innovation, uncertainty and social sciences. Management and Organizational Studies, 5(4), 26-31.

Shahidan, N. H., Latiff, A. S. A., & Wahab, S. A. (2021). Moving towards society 5.0: a bibliometric and visualization analysis. In *Society 5.0: First International Conference, Society 5.0 2021, Virtual Event, June 22–24, 2021, Revised Selected Papers 1* (pp. 93-104). Springer International Publishing.

Shemshack, A., Spector, J.M. A systematic literature review of personalized learning terms. *Smart Learn. Environ.* 7, 33 (2020). https://doi.org/10.1186/s40561-020-00140-9.

Shulga, T. I., Li, Y. J., Krokhina, J. A., Semenov, S. V., Ryazanovae, E. L., & Baranova, E. A. (2021). Digital Technologies' Impacts on Student Social Adaptation During Coronavirus Pandemic. World Journal on Educational Technology: Current Issues, 13(4), 740–748. https://doi.org/10.18844/wjet.v13i4.6261.

Tinmaz, H., Fanea-Ivanovici, M., & Baber, H. (2022). A snapshot of digital literacy. *Library Hi Tech News.*

Verina, N., & Titko, J. (2019). Digital transformation: conceptual framework. In *Proc. of the Int.Scientific Conference "Contemporary Issues in Business, Management and Economics Engineering* (pp. 9-10).

Wilkinson, S. (1998). Focus group methodology: A review. *International Journal of Social Research Methodology*, 1, 181–203.

Yaraş, Zübeyde & Öztürk, Fikriye. (2022). Society 5.0 in Human Technology Integration: Digital Transformation in Educational Organizations. International Journal of Progressive Education. 18. 2022. 10.29329/ijpe.2022.426.26.

Yin, R. (1989). *Case study research: Design and methods*, 2nd ed. London, UK: Sage Publications Inc.

SOCIETY 5.0: CRAFTING THE FUTURE OF PUBLIC GOVERNANCE

Prayote Songklin[A]

ABSTRACT

This paper explores the intersection of Society 5.0 and public governance, investigating the implications, challenges, and opportunities presented by the integration of advanced technologies into governance structures and processes. Society 5.0, characterized by a human-centric approach to technological innovation, seeks to address societal challenges and enhance well-being through the seamless integration of cyberspace and physical space. The transition from Society 4.0 to Society 5.0 represents a significant shift in governance paradigms, requiring governments to adapt to new technological landscapes and evolving societal needs. Through a comprehensive literature review and document analysis, this paper examines emerging trends in public governance within the context of Society 5.0, including data-driven decision-making, open government initiatives, and digital service delivery. Key findings highlight the transformative potential of Society 5.0 in reshaping public governance towards more decentralized, transparent, and citizen-centric models. However, challenges such as data privacy, digital inequality, and ethical considerations must be addressed to fully realize the benefits of Society 5.0. The paper concludes with practical recommendations for policymakers and public administrators, emphasizing the importance of embracing technological innovation and fostering collaboration to build a more inclusive and sustainable society in the digital age.

INTRODUCTION

Background

1. Briefly introduce the concept of Society 5.0

Society 5.0 is a visionary concept proposed by the Japanese government, aiming to create a human-centered society that integrates cyberspace (virtual space) and physical space. This initiative seeks to solve societal challenges by leveraging the advancements of the Fourth Industrial Revolution, such as artificial intelligence (AI), the Internet of Things (IoT), robotics, and big data. Unlike Society 4.0, which focused on the information society and the digital economy, Society 5.0 envisions a super-smart society where technology enhances human life and addresses pressing issues like aging populations, environmental sustainability, and economic disparity (Keidanren, 2016).

[A] *Assoc. Prof., Ph.D., College of Politics and Governance, Mahasarakham University, Maha Sarakham, Thailand. Email: prayote@msu.ac.th Orcid: https://orcid.org/0000-0001-5730-3270*

2. Discuss the importance of public governance in the context of Society 5.0

Public governance plays a crucial role in the realization of Society 5.0. Effective governance ensures that technological advancements are harnessed in ways that benefit society as a whole. It involves creating policies that promote innovation while safeguarding public interests, such as data privacy, security, and ethical standards (Osborne, 2000). Governance frameworks must adapt to support new economic models, address digital divides, and ensure that all citizens can participate in and benefit from technological advancements. In this context, public governance is not just about managing resources and services but also about fostering an inclusive and sustainable society (Anthopoulos, 2017).

3. State the objectives and significance of the research

The primary objective of this research is to explore how Society 5.0 impacts public governance and to identify strategies for adapting governance frameworks to meet the demands of this new societal paradigm. The significance of this research lies in its potential to inform policymakers and public administrators about the necessary changes in governance structures and processes. By understanding the challenges and opportunities presented by Society 5.0, stakeholders can develop more responsive, efficient, and inclusive governance models that enhance societal well-being.

Problem Statement

1. Explain the challenges and opportunities that Society 5.0 presents to public governance

Society 5.0 presents numerous challenges for public governance, including:

(1) Data Privacy and Security: With the increased use of AI, IoT, and big data, safeguarding citizens' data becomes paramount to prevent breaches and misuse (Solms & Niekerk, 2013).

(2) Digital Divide: Ensuring equal access to digital technologies and addressing disparities in digital literacy are critical to prevent societal fragmentation (van Dijk, 2020).

(3) Resistance to Change: Traditional governance structures may resist technological integration, requiring cultural and organizational shifts (Eggers & Bellman, 2015).

(4) Ethical and Legal Issues: New technologies bring forth ethical dilemmas and legal uncertainties that need to be addressed through updated regulations (Floridi et al., 2018).

Conversely, Society 5.0 offers significant opportunities:

(1) Enhanced Service Delivery: Digital technologies can streamline public services, making them more efficient and accessible (Dunleavy et al., 2006).

(2) Increased Transparency: Technologies like blockchain can enhance transparency and reduce corruption in public administration (Tapscott & Tapscott, 2016).

(3) Greater Citizen Engagement: Digital platforms can facilitate more robust citizen participation in governance processes (Bertot, Jaeger, & Hansen, 2012).

(4) Data-Driven Decision Making: Advanced analytics can support more informed and effective policy-making (Kitchin, 2014).

2. Highlight the gap in the current research that this paper aims to fill

Current research often focuses on the technological aspects of Society 5.0 or its applications in specific sectors such as healthcare and industry. However, there is a lack of comprehensive studies examining its implications for public governance. This paper aims to fill this gap by providing a detailed analysis of how Society 5.0 influences public governance structures and practices, and by offering practical recommendations for policymakers and administrators (Janowski, 2015).

Research Questions

1. What are the key elements of Society 5.0 that influence public governance?
2. How can public governance evolve to meet the demands of Society 5.0?

Structure of the Paper

The paper is structured into five key sections to systematically address the research objectives and provide a coherent flow of information:

1. Introduction: Sets the stage for the research by introducing Society 5.0, its relevance to public governance, the research objectives, problem statement, research questions, and the structure of the paper.

2 Literature Review: Examines existing studies and theoretical frameworks related to Society 5.0 and public governance, providing a foundation for the research.

3. Data and Methodology: Describes the documentary research approach, including the selection and analysis of relevant documents and literature.

4. Results and Discussion: Presents the key findings from the literature review and document analysis, highlighting the impact of Society 5.0 on public governance.

5. Conclusion: Summarizes the key points discussed in the paper, provides practical recommendations for policymakers and public administrators, suggests areas for future research, and reflects on the broader implications of Society 5.0 for society and governance.

LITERATURE REVIEW

Concept of Society 5.0

1. Define Society 5.0 and its foundational principles

Society 5.0 represents a human-centered society that integrates cyberspace and physical space, aiming to achieve a balance between economic advancement and the resolution of social problems. It emphasizes the utilization of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, and big data to address societal challenges and enhance human well-being (Keidanren, 2016).

Society 5.0 is built upon several foundational principles:

(1) Human-Centric Approach: Putting human needs and values at the center of technological advancements to improve quality of life and promote social inclusivity.

(2) Integration of Physical and Virtual Spaces: Blurring the boundaries between the physical and virtual worlds through the seamless integration of digital technologies into daily life.

(3) Innovation and Sustainability: Encouraging continuous innovation while ensuring environmental sustainability and social equity.

(4) Data-Driven Decision Making: Leveraging data analytics and AI to inform evidence-based policy-making and enhance efficiency in various sectors (European Commission, 2020).

2. Explore the transition from Society 4.0 to Society 5.0

The transition from Society 4.0 to Society 5.0 represents a significant shift in societal paradigms. While Society 4.0 focused primarily on the digital economy and the proliferation of information and communication technologies (ICT), Society 5.0 goes beyond technological advancements to address broader societal challenges such as aging populations, environmental sustainability, and economic disparity.

In Society 4.0, the emphasis was on digital transformation and economic growth driven by technological innovations. However, Society 5.0 takes a more holistic approach, seeking to harness the power of technology to create a more inclusive and sustainable society. This transition involves not only technological advancements but also changes in mindset, values, and governance structures to ensure that the benefits of technology are distributed equitably across society (World Economic Forum, 2019).

Public Governance

1. Define public governance and its traditional and contemporary models

Public governance refers to the processes, structures, and institutions through which public policy decisions are made and implemented. Traditionally, public governance has been characterized by hierarchical structures and centralized decision-making, where government agencies are responsible for policy formulation and implementation (Osborne, 2000).

However, contemporary models of public governance emphasize decentralization, transparency, and citizen engagement. These models recognize the importance of collaboration between government, civil society, and the private sector in addressing complex societal challenges. They also emphasize the use of technology to enhance efficiency, accountability, and citizen participation in governance processes (Rhodes, 1996).

2. Examine the role of technology in modern public governance

Technology plays a transformative role in modern public governance, enabling governments to deliver services more efficiently, enhance transparency and accountability, and engage citizens in decision-making processes. Key technologies shaping modern public governance include:

(1) Digital Platforms: Governments use digital platforms to deliver services, engage citizens, and facilitate communication and collaboration between government agencies and stakeholders (Bertot, Jaeger, & Grimes, 2010).

(2) Data Analytics: Governments collect and analyze large volumes of data to inform evidence-based policy-making, monitor program performance, and identify emerging trends and patterns (Giest, 2017).

(3) Blockchain: Blockchain technology is being explored for its potential to enhance transparency, security, and efficiency in areas such as identity management, supply chain management, and public procurement (Swan, 2015).

These technologies have the potential to transform public governance by enabling greater efficiency, transparency, and citizen participation in decision-making processes.

Intersection of Society 5.0 and Public Governance

1. Review existing studies on how Society 5.0 impacts public governance

Existing studies on the intersection of Society 5.0 and public governance highlight the potential of advanced technologies to transform governance structures and processes. These studies emphasize the need for governments to adapt to the changing technological landscape by embracing innovation, fostering collaboration, and enhancing transparency and accountability (Mergel, Edelmann, & Haug, 2019).

2. Discuss the theoretical frameworks relevant to this intersection

Theoretical frameworks relevant to the intersection of Society 5.0 and public governance include:

(1) Institutional Theory: This framework explores how institutions shape governance structures and processes, and how technological advancements influence institutional change (North, 1990).

(2) Innovation Theory: This framework examines how innovation occurs within organizations and society, and how governments can foster innovation through policies and strategies (Rogers, 2003).

(3) Network Theory: This framework focuses on the relationships and interactions between actors in governance networks, and how technological platforms facilitate collaboration and information exchange (Rhodes, 1996).

These theoretical perspectives provide insights into the dynamics of technological change and its implications for public governance.

Case Studies and Best Practices

Provide examples of countries or regions that have successfully integrated elements of Society 5.0 into public governance:

1. Singapore: Singapore has leveraged technology to create a Smart Nation, integrating IoT, AI, and data analytics into various aspects of public governance to enhance efficiency, sustainability, and quality of life (Koh, 2018).

2. Estonia: Estonia is recognized for its advanced e-Government systems, including digital ID, e-voting, and blockchain-based services, which have streamlined administrative processes and improved citizen engagement (Lepik, 2017).

3. South Korea: South Korea's Smart Cities initiative focuses on using technology to address urban challenges such as traffic congestion, energy efficiency, and public safety, enhancing the quality of life for citizens (Kim, Lee, & Han, 2019).

These case studies demonstrate how countries are embracing the principles of Society 5.0 to create more innovative, inclusive, and sustainable governance systems.

DATA AND METHODOLOGY

Research Design

The research adopts a qualitative, documentary analysis approach. This method involves systematically reviewing and interpreting various documents to understand how Society 5.0 principles are integrated into public governance. This qualitative approach allows for an in-depth exploration of the complex interactions and outcomes associated with digital transformation in governance.

Data Collection

The documentary research approach relies on a diverse range of sources to gather relevant documents and literature for analysis. This section outlines the sources used in this study, providing insights into the breadth and depth of the literature reviewed.

1. Academic Articles: Peer-reviewed journal articles and conference papers that discuss theoretical frameworks, empirical studies, and case studies related to Society 5.0 and public governance.

2. Government Reports: Official publications from national and local governments detailing strategies, policies, and initiatives aimed at incorporating digital technologies into governance.

3. Case Studies: Detailed examinations of specific projects or initiatives that illustrate the application of Society 5.0 principles in public governance settings.

4. Industry Reports: Publications from think tanks, consultancy firms, and technology providers that offer insights into trends, challenges, and best practices in digital governance.

Data Analysis

An analytical framework is essential for systematically analyzing and interpreting the data collected through documentary research. This section describes the analytical framework employed in this study, outlining its key components and methodological approach.

1. Thematic Analysis: This method was used to identify and analyze key themes and patterns within the documents. Themes related to digital transformation, citizen engagement, collaboration, and ethical governance were particularly focused on.

2. Content Analysis: This method involved systematically coding and categorizing the content of the documents to quantify the presence of specific concepts and ideas. Content analysis helped in understanding the frequency and distribution of various themes across different documents and contexts.

RESULTS AND DISCUSSION

Key Findings

1. Summarize the main findings from the literature review and document analysis

The literature review and document analysis revealed several key findings regarding the impact of Society 5.0 on public governance:

(1) Transformation of Governance Structures: Society 5.0 is reshaping traditional governance structures, moving towards more decentralized and networked models that emphasize collaboration and citizen participation (Anthopoulos, 2017).

(2) Enhanced Service Delivery: Advanced technologies such as AI, IoT, and blockchain are enabling governments to deliver services more efficiently and effectively, improving citizen satisfaction and trust in public institutions (Dunleavy et al., 2006).

(3) Increased Transparency and Accountability: Digital platforms and blockchain technology are enhancing transparency and accountability in public governance by providing real-time access to information and ensuring the integrity of public records (Bertot, Jaeger, & Grimes, 2010).

(4) Challenges of Digital Transformation: Despite the benefits, the digital transformation of governance presents challenges such as data privacy concerns, cybersecurity risks, and the digital divide, which must be addressed to ensure equitable access and protect citizens' rights (Floridi et al., 2018).

2. Highlight the impact of Society 5.0 on public governance

Overall, Society 5.0 is revolutionizing public governance by leveraging advanced technologies to create more responsive, transparent, and citizen-centric governance systems. This transformation has the potential to enhance service delivery, promote innovation, and improve the overall quality of life for citizens. However, it also poses challenges that require careful consideration and strategic planning to address effectively.

Emerging Trends

1. Identify and discuss emerging trends in public governance within the context of Society 5.0

Emerging trends in public governance within the context of Society 5.0 include:

(1) Data-driven Decision Making: Governments are increasingly using data analytics and AI to inform evidence-based decision-making processes, leading to more efficient resource allocation and policy formulation (Giest, 2017).

(2) Open Government Initiatives: Open government initiatives are gaining traction, with governments adopting measures to increase transparency, citizen participation, and collaboration through digital platforms and open data initiatives (Bertot, Jaeger, & Hansen, 2012).

(3) Digital Transformation of Service Delivery: Governments are digitizing public services and implementing e-Government solutions to streamline administrative processes, improve service quality, and enhance citizen satisfaction (UN DESA, 2018).

2. Discuss the implications of these trends for policymakers and public administrators

These trends have significant implications for policymakers and public administrators:

(1) Policy Innovation: Policymakers need to embrace innovation and adopt agile policymaking approaches to keep pace with technological advancements and address emerging societal challenges (Eggers & Bellman, 2015).

(2) Capacity Building: Public administrators must acquire the necessary digital skills and competencies to effectively leverage technology and manage digital transformation initiatives within their organizations (Mergel, Edelmann, & Haug, 2019).

(3) Collaboration and Partnerships: Collaboration between government agencies, civil society organizations, and the private sector is essential to drive innovation and deliver more integrated and citizen-centric services (Tapscott & Tapscott, 2016).

Challenges and Opportunities

1. Analyze the challenges faced by public governance in adapting to Society 5.0

Challenges faced by public governance in adapting to Society 5.0 include:

(1) Data Privacy and Security: Ensuring the protection of citizens' data and mitigating cybersecurity risks are critical challenges in the digital age (Solms & Niekerk, 2013).

(2) Digital Divide: Addressing disparities in access to digital technologies and promoting digital literacy are essential to prevent marginalization and ensure equitable access to opportunities (van Dijk, 2020).

(3) Ethical and Legal Issues: The ethical implications of AI, IoT, and other emerging technologies raise concerns about privacy, discrimination, and accountability, requiring robust regulatory frameworks and ethical guidelines (Floridi et al., 2018).

2. Explore potential opportunities for innovation and improvement

Despite these challenges, Society 5.0 presents opportunities for innovation and improvement in public governance:

(1) Inclusive Governance: Digital technologies can facilitate greater citizen engagement and participation in governance processes, leading to more inclusive and responsive decision-making (Bertot, Jaeger, & Grimes, 2010).

(2) Efficiency and Effectiveness: The adoption of digital platforms and data-driven approaches can improve the efficiency and effectiveness of public services, resulting in cost savings and better outcomes for citizens (Dunleavy et al., 2006).

(3) Collaborative Governance: Collaboration between government, academia, industry, and civil society can foster innovation and co-create solutions to complex societal challenges, leveraging the collective intelligence and resources of diverse stakeholders (Koh, 2018).

CONCLUSION

Summary of Findings

1. Recap the key points discussed in the paper

Throughout this paper, we have explored the intersection of Society 5.0 and public governance, examining its implications, challenges, and opportunities. Key findings include:

(1) Society 5.0 represents a paradigm shift towards a human-centric society that integrates advanced technologies to address societal challenges.

(2) The transition from Society 4.0 to Society 5.0 involves not only technological advancements but also changes in governance structures and processes.

(3) Public governance is evolving towards more decentralized, transparent, and citizen-centric models, driven by digital transformation and technological innovation.

(4) Emerging trends such as data-driven decision-making, open government initiatives, and digital service delivery are reshaping public governance practices.

(5) Challenges include data privacy and security, the digital divide, and ethical and legal considerations, which require careful attention and strategic responses.

(6) Opportunities for innovation and improvement lie in inclusive governance, efficiency gains, and collaborative approaches to addressing societal challenges.

2. Emphasize the significance of the findings in the context of Society 5.0 and public governance

The findings underscore the transformative potential of Society 5.0 in reshaping public governance for the better. By leveraging advanced technologies and adopting innovative approaches, governments can enhance service delivery, promote transparency and accountability, and foster greater citizen participation. However, addressing challenges such as data privacy, digital inequality, and ethical concerns is crucial to realizing the full benefits of Society 5.0. Overall, this research highlights the importance of embracing technological innovation and adapting governance structures to meet the evolving needs of society in the digital age.

Recommendations

1. Provide practical recommendations for policymakers and public administrators

(1) Invest in Digital Literacy: Governments should invest in digital literacy programs to ensure that citizens have the skills and knowledge to fully participate in the digital society.

(2) Promote Collaboration: Foster collaboration between government agencies, civil society organizations, and the private sector to co-create innovative solutions to complex societal challenges.

(3) Strengthen Data Protection: Implement robust data protection measures and ethical guidelines to safeguard citizens' privacy and ensure the responsible use of data in governance processes.

(4) Embrace Agile Governance: Adopt agile governance practices that enable flexibility and adaptability in responding to rapid technological advancements and changing societal needs.

2. Suggest areas for future research

(1) Impact Assessment: Conduct in-depth studies to assess the impact of Society 5.0 on various aspects of public governance, including service delivery, citizen engagement, and policy effectiveness.

(2) Governance Innovation: Explore innovative governance models and practices emerging in the context of Society 5.0, such as participatory budgeting, crowdsourcing, and algorithmic governance.

(3) Policy Evaluation: Evaluate the effectiveness of policies and strategies aimed at promoting digital transformation and enhancing governance outcomes in the digital age.

(4) Ethical Considerations: Investigate the ethical implications of emerging technologies in public governance and develop frameworks for ethical decision-making and governance.

3. Final Thoughts

Society 5.0 holds immense promise for creating a more inclusive, sustainable, and equitable society. By harnessing the power of technology and innovation, we can address pressing societal challenges and improve the well-being of all citizens. However, realizing this vision requires bold leadership, strategic planning, and collective action. It is imperative that policymakers, public administrators, and citizens alike embrace the changes needed to build a future where technology serves humanity and enhances governance for the benefit of all.

As we navigate the complexities of the digital age, we must embrace the opportunities afforded by Society 5.0 while addressing its challenges with foresight and determination. This requires a commitment to continuous learning, adaptation, and collaboration across sectors and borders. Together, we can harness the transformative power of technology to build a more resilient, inclusive, and sustainable future for generations to come. Let us seize this moment to reimagine governance for the digital era and pave the way for a Society 5.0 that truly serves the needs and aspirations of all.

REFERENCES

Anthopoulos, L. (2017). *Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick?* Springer.

Bertot, J. C., Jaeger, P. T., & Grimes, J. M. (2010). Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. *Government Information Quarterly*, 27(3), 264-271.

Bertot, J. C., Jaeger, P. T., & Hansen, D. (2012). The impact of policies on government social media usage: Issues, challenges, and recommendations. *Government Information Quarterly*, 29(1), 30-40.

Dunleavy, P., Margetts, H., Bastow, S., & Tinkler, J. (2006). *Digital Era Governance: IT Corporations, the State, and e-Government*. Oxford University Press.

Eggers, W. D., & Bellman, J. (2015). *The Journey to Government's Digital Transformation*. Deloitte University Press.

European Commission. (2020). *Shaping Europe's Digital Future: The European Digital Strategy*. Retrieved from https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/shaping-europes-digital-future-european-digital-strategy_en

Floridi, L., Cowls, J., King, T. C., et al. (2018). AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations. *Minds and Machines*, 28, 689-707.

Floridi, L., Taddeo, M., & Turilli, M. (2018). *The Ethics of Information*. Oxford University Press.

Giest, S. (2017). The Datafication of Government: How Technology Enables Policy by Algorithm. *Social Science Computer Review*, 35(4), 526-543.

Janowski, T. (2015). Digital Government Evolution: From Transformation to Contextualization. *Government Information Quarterly*, 32(3), 221-236.

Keidanren. (2016). *Toward Realization of the New Economy and Society*. Japan Business Federation.

Kim, Y., Lee, J., & Han, S. (2019). The Conceptual Framework and Policy of the Korean Government's Smart City. *Sustainability*, 11(1), 211.

Kitchin, R. (2014). *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*. Sage Publications.

Koh, S. C. L. (2018). Singapore as a smart nation: Implications for public management and public governance. *International Journal of Public Sector Management*, 31(2), 189-205.

Lepik, K. L. (2017). Digital Estonia: How one country is reaping economic benefits from becoming 'e-Estonia'. *European Journal of Public Sector Management*, 31(3), 245-260.

Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government Information Quarterly*, 36(4), 101385.

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge University Press.

Osborne, S. P. (2000). *Public-Private Partnerships: Theory and Practice in International Perspective*. Routledge.

Rhodes, R. A. W. (1996). The New Governance: Governing without Government. *Political Studies*, 44(4), 652-667.

Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.

Solms, R. von, & Niekerk, J. van. (2013). From information security to cyber security. *Computers & Security*, 38, 97-102.

Swan, M. (2015). *Blockchain: Blueprint for a New Economy*. O'Reilly Media.

Tapscott, D., & Tapscott, A. (2016). *Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World*. Penguin.

UN DESA. (2018). *United Nations E-Government Survey 2018: Gearing E-Government to Support Transformation towards Sustainable and Resilient Societies*. United Nations Department of Economic and Social Affairs.

van Dijk, J. (2020). *The Digital Divide*. Polity Press.

World Economic Forum. (2019). *The Global Competitiveness Report 2019*. World Economic Forum.

CREATING NEW STRATEGIC APPROACHES FOR VIRTUAL LEARNER-CENTERED GROUP PROJECTS WITH ARTIFICIAL INTELLIGENCE (AI)

Dr. Bob Barrett[A], Chelby Miller[B]

ABSTRACT

While many educational institutions have moved from traditional Face-to-Face (F2F) learning to online learning or a hybrid version, they are also trying to transition from the traditional teacher-centered approach to a more student-centered learning approach in education. This paper will address the following items for more clarification of this process. 1) Introduction/Objective. The main objective of this paper will be to examine how traditional methods of group projects can be transitioned over to an online learning classroom to help strengthen the use of role-playing and learning in the online learning environment. 2) Methods. Students will be introduced to several key topics for a group project with a student-centered approach to give them more breadth and depth for exploration an examination of the selected topic and instructed possible ways of using Artificial Intelligence (AI) to help them search for possible outcome and solutions for their selected topic area. 3) Result. Students will develop both a presentation of their findings, along with a formal paper of their processes followed during their group project, along with a debriefing of lessons learned from their experiences. 4) Conclusion. The outcome of the learning experience from the students' perspectives will help others to understand whether the student-centered approach can be helpful or need additional directions in this type of learning environment

Keywords: *Online learning, Artificial Intelligences, Group project, Traditional Learning, Role-playing*

INTRODUCTION

The predecessor to online learning was distance education. In 1728, Caleb Philipps, a shorthand teacher, offered shorthand courses by mail (Oxford College, 2024). Later, Isaac Pitman developed a form of stenography called Pitman Shorthand in 1837, which would become more easily accessible from the U.K. to America in the 1840s as a correspondence course later to be called distance education (Norman, 2024). This was only the beginning of several changes in the field of distance education which occurred over the period of 1728 to 1990. At the same time, the term distance education changed to what is now referred to as online learning or virtual learning. For the purposes of this paper, the term online learning will be the key focal term used for courses taken, in the non-traditional sense, i.e., without walls, borderless, or in the realm of

[A] *Doctorate of Education (Ed.D.), Human Resource Development Highest academic education, department, university, state, country. Email: docjob00@msn.com Orcid: https://orcid.org/0000-0002-0627-8439*

[B] *Master of Business Administration, College of Graduate Studies, Baker College, Michigan, United States of America. Email: cmille99@baker.edu Orcid: https://orcid.org/0009-0003-8616-411X*

a virtual environment. Towards the latter part of the 20th century, technological improvements promoted the evolution of distance education and virtual learning with the offering of new software management systems known as Learning Management Systems (LMS). This helped to facilitate the learning process from the traditional physical environment, referred to as face-to-face (F2F) learning environment.

While the evolution of learning from the days of Socrates has occurred at a rapid pace with the onset of changing technology in the past two decades, there is yet another movement in education to transfer the power of learning from the traditional method of instruction, known as Teacher-Center Learning (TCL) to Student-Centered Learning (SCL).(Woods & Copur-Gencturk, 2023) Traditionally, the teacher-centered learning approach has been used for centuries since the time of Socrates. At its core, the TCL approach focuses on the teacher as the center point of education, who oversees the facilitation of learning to the students as knowledge receptacles. Key elements of the TCL approach are the syllabus, learning objectives, learning activities, and discussions, as well as any type of assessment instruments, including quizzes, examinations, or other ways of testing the students' content knowledge or application of the knowledge to a given scenario or assignment. It should be noted that many people have fallen into a cookie cutter approach with the TCL approach in which they think this is the one and only way to facilitate learning and to measure learning with students. Nonetheless, there have been challenges over the years, and a newer approach, known as the student-centered learning approach. has gained more momentum in comparison with the pre-pandemic years.

During the COVID-19 pandemic, many people were forced into remote learning modalities, because of the global health crisis. During this time, many people may not have been using any type of online learning software or learning management system, known as LMS, and as a result they were rushing to learn this system, or systems, as quickly as they could. Therefore, the challenge to the traditional TCL approach was basically put on hold. (Altun, 2023) One reason for the moratorium on changing teaching styles or learning approaches at this time was due to the pandemic and the sudden technological changes for many instructors. However, some instructors were very creative given that they may have had multiple classes with students that may have presented challenges and needed more connection with other students during this time of physical isolation Thus, some instructors decided to adopt the idea of a student-centered learning approach in which they could divide up students into project groups or teams for them to work virtually, which some in the business world would call virtual teams or virtual management of teams and which did provide an excellent new age approach to education. The goal of this paper is to look at how instruction could be accomplished in a remote learning environment through student interaction in the form of team activities, as well as the accomplishment of learning objectives through learning activities that allow students to feel more empowered and motivated about their learning and which will give them a better sense of ownership. It has been documented in several studies about student centered learning that this type of approach empowers students and gives them a sense of ownership in which they can control to a degree they're learning. At the same time, the students can still rely on a facilitator or educator to be there when they need them to proceed to the next steps, fostering a more collaborative learning journey for the student. (Sjølie, Strømme, Boks-Vlemmix, November 2021).

Student-Center Learning

According to Resilient Educator (2020), this type of learning environment has a different assignment of roles and responsibilities. First, the the role of a facilitator is changed and sometimes varies. The facilitator, or educator, may work from the sidelines, alongside the

students or teams, or from a distance, depending on the requirements of the course syllabus, as well as the teacher's strategic approach to the course environment, course content, and overall management of the learners.(Midgette, 2024) It should be noted that the role of the educator is not to be a micromanager, but a facilitator of the learning process. With that being said, sometimes the lines can become blurred between the facilitator's interpretation, additional roles to fill, and the students' perception of the facilitator's style of instruction and approach to the learning environment. As such, this opens a new door for a paradigm shift in the educational process, in which the facilitator and the learner need to dialogue more than ever before to understand their assigned roles and responsibilities on both parts of the learning process. Later in this paper, the discussion of a team charter will help to outline more of what is required for a successful learner-facilitator dialogue and the process to help learners achieve project and time management, as well as improving the overall learning experience and journey. (L&D Hero, 2023)

Understanding the Learner's Perspective

Some educators and educational administrators have questioned the movement from the traditional teacher-center learning approach to that of a student-centered approach over the past several years. While it has been applied in various educational settings ranging from K-12 to higher educational institutions, there have been both successes and failures in implementing such an approach. Prior to passing judgement on the approach, it is critical to examine the expected outcomes for the learner and their perspective. Historically, the learner has been taught to listen and obey the instruction of the educator, however, there are several studies that show that the traditional methods may not always be functional or applicable, as evidenced by higher instances of behavioral problems in the classroom. (Wang, 2022). For example, prior to the integration of students with disabilities into the mainstream classroom, these students were capped in separate classrooms or in institutions away from their peers. It took years to de-program educational thought regarding disabilities to gain acceptance for students with various types of disabilities. While we could go into various laws, rules, and regulations that were applicable prior to the Americans with Disabilities Act of 1990, such a discussion could easily be developed into a whole series of books, rather than one paper. For the purposes of this paper, we will note that all students, with or without disabilities, can benefit from this student-centered learning approach. We will now delve into additional discussion as to what student-centered learning is and what this type of learning approach can achieve for the education of today's students.

The key benefits of utilizing a student-centered approach is to first give learners more of a "voice" in their learning journey. Second, it offers both the instructor and student more flexibility in the classroom with the goal of improving their sense of autonomy in the learning process. Finally in terms of motivation, this approach allows them to develop and nurture their own learning, thus promoting the formation of "ownership" and accountability for their learning. (Barrett & Miller, 2024; Resilient Educator, 2020) Thus, whether one choses TCL or SCL, the design and development of the learning activities will be critical to reinforce such learning approach. Why is this important? Well, the lack of proper planning can result in a design of the learning environment to either enhance, detract or stagnate learning. (Barrett & Miller, 2024) Further, sometimes the distinction between the use of student-centered learning over teacher-centered learning is misunderstood, poorly implemented, or evaluated incorrectly by the facilitator or educational administration. For example, there are a number of eductional institutions that tout the use of a fully student-centered learning approach, but they do not "administer or offer" a complete student-centered learning approach, such as still offering a

regimented syllabus and list of assignments with only "slight" flexibility for student ownership of their learning.

Furthermore, this means that these educators and educational administrators are not offering a pure form of student-centered learning strategy in their learning environment. For the purposes of this paper, the authors will be addressing a hybrid format with the crossover from teacher-centered learning to student-centered learning approaches. Bowers (1995), wrote "today, professors of education and classroom teachers continue to ignore the possibility that the ecological crisis might have profound implications for rethinking core liberal assumptions that make the student's direct experience the epicenter of the learning process" (1995, p. 16). Basically, the learning approach may be more beneficial if the instructor can assess which type of learning approach would most benefit the student's overall content knowledge acquisition, as well as for the long-term sustainability of their knowledge by fostering a passion for lifelong learning.

Additionally, it should be stated that, in the traditional teacher-centered learning (TCL) approach, the prescribed learning activities are defined by the educator. On the other hand, as changes and challenges occur in the educational world in the area of student-centered learning (SCL), the varous players, events, and tools for learning have changed and can change during the given learning event(s). Thus, there now exists a need to help prepare current and future educators who may be required to adopt or adapt to SCL to be able to use new approaches, strategies, methodologies, and/or AI applications. One of the key learning activities used in the SCL approach is group or team learning, although not all instructors are proponents of group projects and will try to avoid the use of this format for learning (Barrett & Miller, 2024). In the next segment of this paper, the authors will outlinethe research methods, strategies, and approaches with the use of team or group learning activities in the learning environment to provide a context as to how the student-centered learning (SCL) approach can be beneficial in terms of motivation, empowerment, and developing team-building relationships in a classroom setting whether it be in a Face-to-Face (F2F) or remote learning environment.

RESEARCH METHODOLOGY

Before entering into a detailed overview of the methodology used to evaluate the overall impact of SCL with the use of team-based projects, we need to consider a baseline as to what constitutes a best practice and why educators need to consider memorializing such practices for others to learn more about what is happening in today's classroom, especially regarding what does or does not work well. Consequently, it is important to state that not all best practices fit all organizations, situations or players involved. However, for the purposes of this paper, the authors will share what they have discovered and examined in a number of terms with course work that required the use of team-based projects with a SCL approach.

BEST PRACTICES FOR CONSIDERATION

Before recommending best practices for consideration, we must first understand the concept and importance of "best practices." According to Merriam-Webster.com (2023), best practices are "a procedure that has been shown by research and experience to produce optimal results and that is established or proposed as a standard suitable for widespread adoption." Jones (1993) described best practices as centered "on the very essence of good management: guiding employees toward greater productivity, liberating them from the burdens of disorganization

without saddling them with restrictive bureaucracy, and helping them to overcome some measure of the troublesome flaws inherent in people and processes. These are the measures of effectiveness and efficiency"

Barrett (1999) noted the use of such practices in his dissertation on Best Employment Disabilities Practices (BDEP). In fact, for some organizations the development of best practices is a great accolade for them to stand by as part of their own memorialization of the events and how they handled various situations(s). This leads to the next looming question regarding the current best practices of uses of student-centered learning (SCL) in today's classroom. During the Covid-19 Pandemic Period, Barrett (2022) developed a list of educational best practices to be used during a period of crisis, which can be applicable in many educational settings. The following is a summation of Barrett's Crisis Readjustment Best Practices (CRBP):

- Ability to adjust teaching environments with more "planned" transitional skills sets.
- Coordinate ongoing coaching/mentoring for all new instructors on a regular basis, rather than on an as-needed basis.
- Continuous evaluation of teaching methodologies for new and current educators, as well as pairing up potential teaching mentors.
- Sharing practices across departments and academic institutions, both nationally and globally.
- Preparing publications for sharing such best practices for traditional publishing opportunities as well as open access venues.
- Setting up a committee to do future crisis/risk management assessments for educational offerings to prepare for any potential challenges or issues that could impact all stakeholders in the educational process. (Barrett, 2022)

While this list of best practices was originally limited to use with situations during crisis, it could be argued to a degree that, in light of budgetary cuts, declining enrollments, and ever-changing laws and regulations, education as a whole continues to remain in state of continuous crisis. Thus, this is only a preliminary list of best practices in education which could be used in different types of learning approaches and environments. Since the parameters of this paper are limited in scope, one more of these best practices will be explored for their practical application of the learning process for this discussion of team/group learning activities used in a student-centered learning (SCL) approach. In the next segment of this paper, the authors will outline their approach to the main learning assignment for student-centered learning from its inception through implementation and evaluation.

GROUP/TEAM LEARNING ACTIVITIES

Here is an overview of the following segments surrounding the team learning activity that involves all class members. First, we will look at the SCL approach in connect to its contextual application with the group/team learning activities. Next, there will be an examination of why a team charter is used in this type of student learning activities,. Finally, the last segment will look at the application of project management skills and approaches with the team selected project.

Introduction of Student-Center Learning Approach

The instructor's key role for this type of approach isdrastically different to what most student's have experienced up to this point.. The educator will explain that his or her role will

be that of a facilitator to help them move from point A to point B and beyond throughout their given assignment. This may be a novel approach for many students; as such, the instructor should bear in mind to start from Ground Zero and explain the differences between teacher-centered approach versus student-centered approach to learning. After this discussion has been presented to a classroom, the students will then be redirected back to the original course syllabus in which the various learning activities, which have been derived from the learning objectives, will be reviewed. For this paper, the focus will be on a team project, although the terms "group" and "team" may be used interchangeably.

The team project will consist of a certain number of students per team, with each of them being part of a collective movement, such as a given group or team. There will be a series of projects, which will be discussed below, from which the team will be able to select two preferred topics to send as their proposed topic for the teacher's approval. Allowing the teams to send in two preferred topics allows the teacher to better organize the topics across all groups to accommodate individual team interests in relation to the collective demand for each of the available topics. Upon receiving the teacher's approval of one topic, the team will organize itself in a group area to start work on the project.

The following topics are areas for the teams to select from for this student-centered learning approach:

1. Communications Workshop (i.e., interpersonal, business, technical, etc.)
2. Expatriate Training
3. Computer Conversion with New Software Package(s)
4. Human Resource Information Systems (HRIS) Selection and Implementation

As discussed earlier, the teams proposed two selections to the instructor, and the instructor will approve one topic and commence work for this project. The students will then meet in the group area for discussions and to begin work on the project. purposes of this project, we will reference the use of Google Docs as the group area and how it can be used for team organization and project management purposes. In this scenario, as each team is assigned to a project, they will also be assigned to a Google Docs group page. Within Google Docs, there is a section for discussions and pages in which the project can be created, and other documents attached, such as Word documents, Excel spreadsheets, and PowerPoint presentations, although Google Suite has alternative options in the form of Google Slides, Google Sheets, etc. which may be a more intuitive option. The facilitator will take it upon himself or herself to visit these group pages in the Google Docs area to facilitate the background and to make sure that all team members are actively participating in the given project.

The beauty of using Google Docs and their Pages element is simply for alignment as all team members can work on the same document, in either a synchronous or asynchronous fashion, at any given time without having to send documents back and forth. This keeps the document in one central place and updated as each person adds information, with the added benefit of a working history of when changes were made within the document and by whom. This can be quite constructive and time-consuming as it reduces the potential for miscommunication and coordination errors. The Google Pages tool helps to prevent many of the mistakes which have been made by many in the project management task. One of the things that the authors have found useful in such project management is to make sure that there is a game plan, namely a Team Matrix, used to help map out all the roles and responsibilities for each team member to maintain momentum and accountability within the project. For illustrative purposes, the following will outline the key areas that teams may need to map out so that they can meet deadlines with the assigned milestones or any dates that they have selected, if given

the option. This matrix will serve as an informal contract between the instructor and the team in terms of when they will meet each phase of the project along the given timeline. Usually, the matrix is broken down into tasks and milestones on a weekly basis. The Team Matrix normally consists of the following elements:

- Week of the project
- Team members' roles
- Team tasks
- Milestone (date assigned for each task)

It should be noted that some of the assigned roles selected by previously observed teams include:

- Needs Assessment Analyst
- Creators (Design and Development)
- Implementors
- Researchers
- Editors/Proofreaders (Including Grammar, APA Style, etc.)

The Team Matrix is completed collectively and submitted to the instructor for review. Following review by the instructor, it is then returned with comments and approval for the teams to commence work. It is up to each team to monitor all team members in terms of participation and work. However, it should be noted that the instructor still helps in the background as a facilitator of the learning to make sure that the teams are moving along and keeping alignment with the Team Matrix as if they were working in any workplace in today's organizations. This helps to add a layer of real-world working experience to the group project, as well as giving the groups ownership of their learning experience, as this activity simulates working on a major project in the workplace. . Many students have reported that this learning activity is applicable to their personal experiences in the workplace in which utilization of a Team Matrix would have helped them in a past project, would be useful for a current project, or has promise for an upcoming project. This can be proven to be very motivational, engaging, and empowering to the group when they can relate academic work to real world application.

As the students work on the project, there will be problems, issues, and challenges that arise. In line with the taking on the facilitator role, the instructor will be there to help by suggesting other approaches and research that could be beneficial. A common issue which may occur in group projects is social loafing. The instructor should be available to provide guidance in such instances and may want to consider including a participation grade in the rubrics assigned to the final project and presentation to ensure that all team members were actively involved in the process. This is a personal choice given to the instructor that may facilitate a fairer grading approach for each student's actual involvement and contribution to the project. However, it should be noted that the instructor may want to defer to the judgment of the department chair or academic department for further instruction on this type of rubric construction and grading policies. The instructor may also find it beneficial to suggest tools which may help throughout the process. One such tool is the use of artificial intelligence in terms of ChatGPT for brainstorming events. It should be noted that the authors have used ChatGPT in classroom settings to demonstrate to students how it can be used as a tool in an ethical, legal, and responsible manner for brainstorming or mapping out ideas. The next section will discuss how the project is put together for the teacher's review prior to the presentation of the team project.

Project Management of Team Selection

Prior to the conclusion of the class, the team will meet to create two parts of their final project. The first part will be either a PowerPoint or a Google Slides presentation, depending on the team's selected format for the overall project. To give the students a true real-world experience, the instructor will give an option to the team to vote on whether they want to select a specific time to present their final project through a synchronous Zoom meeting or submit a pre-recorded presentation. This option adds a level of student autonomy, in line with the SCL approach, as well as providing additional flexibility to accommodate the students' time constraints rather than trying to rearrange everyone's schedule, a task made more difficult if students are working together across time zones. From the authors' experience, most students prefer the second option, with it being selected almost 95% of the time, especially online students. Interestingly, this same percentage was true prior to, during, and after the pandemic. Therefore, there is strong evidence that adult learners do prefer to manage their own time and work at their own pace, even in a team setting.

The next step for the team is to prepare a paper on the overall topic in a more traditional academic format to accompany the presentation as part of the final project portfolio. Going forward, the use of the term "portfolio" will be used interchangeably with the term e-portfolio, which is the preferred term for documents created by students in the online learning environment. One of the reasons why the authors favor the use of e-portfolios is that it provides a document, or a series of documents, for students to use later when interviewing for jobs to demonstrate proof of their academic work. Basically, these are artifacts of the learning process that will demonstrate to future employers the skills, abilities, and application of content knowledge that the student has applied in their courses.

Finally, the final segment of the project is an individual paper created by each student to acknowledge the issues, challenges, and problems encountered during the student-centered learning approach to the given project. This provides a reflection piece for not only the student, but also for the facilitator to determine if there exists a need for future changes or updates to the course. As for the students, sometimes they are accustomed to simply completing a final project and turning it in with nothing more being said about the process. However, the authors of this paper have discovered over a series of courses that reflection on a project or final project is critical to the learning process of both traditional and non-traditional students. Further, it should be noted that some students may be more reflective of the process over the entire course of the project, whereas other students may want to wait until they have finished the project to truly think back on what they have learned, what could have been changed, or what they would like to see in future courses. In this next section, the authors will look at the results of such an approach with the student-centered learning and the ownership by students and a final project.

RESULTS

While many academic courses focus on the course content and historical and theoretical applications of prior work or published literature, it should be noted that the non-traditional student is more prone to further engagement and motivation when they can see the connection between the course material and the real-world applications. The project discussed in this paper helps to open a new pathway for many online students to experience a different approach to learning. Traditionally, they are accustomed to being assigned a paper with a certain number of instructions and just work on their own. However, when the game plan is changed on them and

they must learn a new way of doing things, it is critical to proceed with compassion, as this is a new approach and does take time to become acclimated to the change. This is especially true when adjusting to working in a team setting, which is not typical of many courses. There will be challenges and issues, as well as other internal and external factors, that may halt, limit, or stop their efforts on a project, but it will be up to the team, as well as the facilitator, to notice various changes in their behaviors of team members and to proactively determine how best to approach the situation, much as if they were working in the real-world on such project.

Over the past several years this approach has been used in two separate graduate courses at a leading online learning program, and it has proven to be quite beneficial. In fact, being able to take the final project, which consists of both a presentation and an academic paper to include in one's e-Portfolio has become an important part of the program of study. The student now has their own e-Portfolio to carry with them on a USB stick or to embed in a link, which can be transmitted via e-mail to a potential employer for review when they want to know more about the student's academic accomplishments. Also, the use of the Team Charter has been ideal for building the foundation for team members to plan out their team or project management approach. Some team members have no experience with project management, so this is a new concept, but one which is crucially important for all business students to understand as many companies are actively seeking candidates with project management and artificial intelligence (AI) skills.

Finally, besides focusing on a team approach, the final paper, which is reflective of the collective effort made by each individual team member, is quite informational. While it has a certain layer of teacher-centered learning approach with predesignated topic options, it should be noted that the main emphasis is really on what the student felt, thought, experienced, and could suggest as future changes to the course. It helps the facilitator to understand whether the student truly felt like they owned their work or whether they may have been carrying the group through the process while others engaged in social loafing behaviors. Also, it helps to uncover to which degree that the student felt either empowered or truly engaged in the overall process for the project. It should be noted that not all students will be completely honest or straightforward with their reflective papers, however, one of the authors has experienced many times over a variety of comments, suggestions, and inspiring accolades and attributes shared about the course and the work of others. While this may not be typical of every workplace setting, as many project teams do not really reflect on a project unless it goes wrong, a debriefing process is always recommended to find out what worked or what did not work. The following section will be a summation of what was found during the process of creating work in the student-centered learning approach, as well as some ideas for future research implications.

CONCLUSION

Traditionally, teacher-centered learning approaches have been the standard, having been used for centuries since the time of Socrates. However, it should be noted that even the Socratic method is under fire by leading academics and society in general. As traditional educators started to see a need for change in the educational system, they knew that any paradigm shift in education would be slow in occurring. However, as outlined through this paper, the evolution of distance education into the arena of online education provided an opportunity for educators to prepare for changes in the educational and business worlds. It should be noted that the pandemic acted as an educational catalyst as well as a global health crisis event. As such, during this period many educators had no choice but to embrace newer technologies related to online

education and think of more creative ways of simulating real-world experiences with their students. Consequently, this paper has highlighted how the writers have witnessed one educational institution's approach to the use of student-centered learning in the framework of assigning teams, selecting from a series of potential projects, creating a team charter to use as a template for the project management task, and working through the team project with the instructor taking on the facilitator role. This paper has demonstrated the process from start to finish from the project management selection to the creation of the Team Matrix, and the various milestones of completion for each role and task so that the reader could see how this could be applicable to many different types of courses. Finally, this overall project provided the facilitator and students with an opportunity to learn more about and from the skills and abilities of one another, as well as their own experiences as individual and team contributors to their academic experience. The authors suggest that this could serve as a template or framework for further research for use in various disciplines and programs of study to further the literature and research in the area of student-centered learning.

REFERENCES

Altun, M. (January 2023). The Ongoing Debate over Teacher Centered Education and Student Centered Education. Tishk International University. DOI: 10.23918/ijsses.v10i1p106

Barrett, B. & Miller, C. (2024). Creating engaging solutions for student-centere learning with artificial intelligence (AI) learaning Strategies to empower students: Constructing real world approaches for the next generation of workers.

Barrett, B. (2023). Creating Ethical, Legal, and Educational Best Practices with the Implementation of Artificial Intelligence and ChatGPT in the Online Learning Environment. Global Education, Teaching and Learning (IAC-GETL), Vienna, Austria.

Barrett, B. (2022). Creating crisis readjustment best practices (CRBP): Stratregies for developing educational transitional practices during environmental readaptation of human capital. EduLearn 2022.

Barrett, B. (1999). BEST DISABILITY EMPLOYMENT PRACTICES: A CASE STUDY. The George Washington University, Doctoral Dissertation. UMI Publications (March 25, 1999).

Bowers, C. A. 1995. Educating for an Ecologically Sustainable Culture: Rethinking Moral Education, Creativity, Intelligence, and Other Modern Orthodoxies. Albany, NY: SUNY Press.

Jones, T.L. (1993). The Americans with disabilities act: A review of best practices. New York:AMA.

L&D Hero (October 27, 2023). The Trainer's Toolbox: A Guide to Effective Facilitation Skills. Retrieved The Trainer's Toolbox: A Guide to Effective Facilitation Skills (workplacehero.co.uk).

Merriam-Webster.com Dictionary (2023). Definition of Best Practices. Retrieved from Best practice Definition & Meaning - Merriam-Webster.

Midgette, L. (2024). Making the sift to teacher as facilitator: A starting conversation. The Center for Professional Education of Teachers (CPET), Teachers College, Columbia

University. Retrieved Making the Shift to Teacher as Facilitator - CENTER FOR THE PROFESSIONAL EDUCATION OF TEACHERS (columbia.edu)

Norman, J. (2024). History of Information.com: Exploring the History of Information and Media through Timelines. Retrieved Pitman Shorthand, & The First "Correspondence Course" : History of Information.

Oxford College (2024). The history of distance learning. Retrieved History of Distance Learning | Online Education Timeline (oxfordcollege.ac).

Resilient Educator, Which is Best: Teacher-Centered or Student-Centered Education?, March 2020. Retrieved from https://resilienteducator.com/classroom-resources/which-is-best-teacher-centered-or-student-centered-education/

Sjølie, E., Strømme, A., Boks-Vlemmix, J. (November 2021). Team-skills training and real-time facilitation as a means for developing student teachers' learning of collaboration. Teaching and Teacher Education, Vol. 107. https://doi.org/10.1016/j.tate.2021.103477

Wang, Yuemeng. (2022). A Comparative Study on the Effectiveness of Traditional and Modern Teaching Methods. 10.2991/978-2-494069-89-3_32.

Woods, P.J., Copur-Gencturk, Y. (February 2023). Examining the role of student-centered versus teacher-centered pedagogical approaches to self-directed learning through teaching. Teaching and Teacher Education, Volume 138, 104415. https://doi.org/10.1016/j.tate.2023.104415.

DOES ARTIFICIAL INTELLIGENCE-ENABLED TRANSFORMATION ACCEPTANCE MATTER IN DIGITAL HIGHER EDUCATION INSTITUTIONS?

Zahir Osman[A], Tuan Fatma Tuan Sulaiman[B], Liana Mohamad[C]

ABSTRACT

This study investigates the factors influencing employee acceptance of AI-enabled transformation in digital HEIs, focusing on the mediating roles of self-efficacy and attitude. Drawing upon the Technology Acceptance Model (TAM), the study examines the direct and indirect relationships between perceived ease of use, perceived usefulness, and acceptance, incorporating self-efficacy and attitude as essential mediators. Primary data was collected through a survey questionnaire distributed to employees of digital HEIs. A total of 422 valid responses were included in the analysis, representing a satisfactory response rate of 78.4%. Structural equation modeling (SEM) was employed using SmartPLS4 software to assess the measurement and structural models and test the proposed hypotheses. The results revealed that perceived ease of use and perceived usefulness directly influence acceptance, with self-efficacy and attitude serving as significant mediators. Importance-performance map analysis (IPMA) further highlighted each latent variable's relative importance and performance in explaining acceptance. To ensure the practical impact of perceived ease of use and perceived usefulness on acceptance, HEIs should focus on fostering self-efficacy and promoting a positive attitude among employees. Providing comprehensive training programs, emphasizing the benefits of AI, and creating a culture of innovation can significantly contribute to the successful adoption of AI-enabled transformation. Future research could explore the longitudinal effects of interventions to enhance employee readiness to change and investigate the role of organizational culture and leadership support in facilitating AI adoption. The findings have important implications for institutional leaders and policymakers, as they can develop targeted strategies to promote the successful integration of artificial intelligence technologies in digital higher education institutions.

Keywords: *Perceived Ease of Use, Perceived Usefulness, Self-Efficacy, Attitude, Acceptance*

INTRODUCTION

Artificial intelligence (AI) has revolutionized digital education in higher education institutions, offering personalized, efficient, and engaging learning experiences (Zawacki-

[A] *PhD, Faculty of Business and Management, Open University Malaysia, Kuala Lumpur, Malaysia. Email: zahir_osman@oum.edu.my Orcid: https://orcid.org/0000-0001-8443-3062*

[B] *PhD, Centre for Quality Assurance, Open University Malaysia, Kuala Lumpur, Malaysia. Email: tuanfatma@oum.edu.my Orcid: https://orcid.org/0009-0004-7946-6854*

[C] *MIT, Faculty of Business and Management, Open University Malaysia, Kuala Lumpur, Malaysia. Email: liana_mohamad@oum.edu.my Orcid: https://orcid.org/0000-0002-6483-7710*

Richter et al., 2019). Institutions increasingly adopt AI to enhance teaching methods, streamline administration, and improve student outcomes (George & Wooden, 2023). A key challenge is employee acceptance of AI-enabled transformation. Overcoming resistance, addressing job security concerns, and providing adequate training is crucial for successful implementation (Ghosh & Bhattacharyya, 2021). Despite AI's advancements, research on factors influencing employee acceptance in higher education remains limited (Zawacki-Richter et al., 2019). Understanding employee acceptance is vital for policymakers, institutions, and employees (Rudolph et al., 2024). Policymakers can use research to develop practical AI integration strategies. Institutions can better navigate challenges and leverage AI benefits (Ghosh & Bhattacharyya, 2021). Employees can use research to embrace AI, improve their work, and adapt to the digital landscape (Huang et al., 2023). This study examines the relationships between perceived usefulness, perceived ease of use, acceptance, self-efficacy, and attitude as mediators among higher education institution employees.

LITERATURE REVIEW

Underpinning Theory

The Technology Acceptance Model (TAM) (Davis, 1989) is a foundational theory explaining how users accept and utilise new technologies. Central to TAM are two fundamental constructs: perceived usefulness (PU) and perceived ease of use (PEOU), both of which significantly influence users' intentions to adopt technology (Aladwan et al., 2023). Notably, PEOU can positively impact PU, suggesting that when users find technology easy to use, they are more likely to perceive it as applicable (Alkindi et al., 2022). Additionally, self-efficacy—the belief in one's ability to effectively use technology—can also play a crucial role in shaping PEOU and PU (Aladwan et al., 2023). This study applies the TAM framework to explore AI adoption in higher education, investigating the direct and indirect relationships among PU, PEOU, acceptance, self-efficacy, and user attitudes. Overall, TAM is a valuable framework for understanding AI acceptance and guiding effective implementation strategies in educational settings.

Relationship between Perceived Ease of Use, Self-Efficacy & Acceptance

The link between perceived ease of use and the acceptance of AI-driven transformations in higher education, with self-efficacy as a mediator, is critical for successful AI integration (AlGerafi et al., 2023). Perceived ease of use, which reflects how user-friendly AI tools are perceived, directly impacts their adoption (Saqr et al., 2023). Educators who view AI tools as easy to use are more inclined to integrate them into their teaching practices, highlighting the importance of intuitive interfaces for fostering acceptance (Tan et al., 2023). This direct relationship emphasizes the need for AI technologies to be accessible and straightforward to enhance user adoption. Additionally, self-efficacy is an individual's belief in their ability to effectively use AI, which mediates the connection between ease of use and acceptance (Shao et al., 2024). Educators with higher self-efficacy are more likely to find AI tools user-friendly, which fosters a positive attitude and greater acceptance (Chahal & Rani, 2022). To improve AI adoption, institutions should enhance self-efficacy through training and support while prioritizing ease of use (Lai et al., 2023). Based on this, the following hypotheses were proposed for this study:

H1: There is a relationship between perceived ease of use and acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

H2: There is a relationship between perceived ease of use and self-efficacy in the acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

H3: There is a relationship between perceived ease of use and perceived usefulness in the acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

H4: There is a relationship between self-efficacy and acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

H5: There is a mediating effect of self-efficacy on the relationship between perceived ease of use and acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

Relationship between Perceived Ease of Use, Attitude & Acceptance

The connection between perceived ease of use and the acceptance of AI-driven transformations in higher education, with attitude as a mediator, is critical for successful AI integration. Perceived ease of use, which reflects how user-friendly and accessible AI tools are perceived, directly influences their acceptance (Rahman & Kodokal, 2024). Educators who find AI tools easy to use are more likely to integrate them into their teaching, highlighting the importance of intuitive interfaces in promoting acceptance (Tan et al., 2023). This direct link underscores the need for AI technologies to be straightforward and user-friendly to facilitate smoother adoption (AlGerafi et al., 2023). Additionally, attitude is vital in mediating the relationship between perceived ease of use and acceptance. A positive attitude toward AI helps bridge the gap between ease of use and adoption (Chahal & Rani, 2022). When educators perceive AI tools as easy to use, it fosters a positive attitude, further enhancing acceptance (Habes et al., 2024). Optimizing this relationship is essential for effective AI implementation strategies in higher education (Bansah & Darko Agyei, 2022). Institutions can overcome adoption challenges and maximize their transformative potential by focusing on user-friendly designs, cultivating positive attitudes, and highlighting AI's practical benefits (Lalicic & Weismayer, 2021). Thus, the following hypotheses were proposed for this study:

H6: There is a relationship between perceived ease of use and attitude in the acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

H7: There is a relationship between attitude and acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

H8: There is a mediating effect of attitude on the relationship between perceived ease of use and acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

Relationship between Perceived Usefulness, Self-Efficacy & Acceptance

The relationship between perceived usefulness and the acceptance of AI-enabled transformations in higher education, with self-efficacy as a mediator, is crucial in successfully adopting AI technologies (Gosh & Bhattacharyya, 2021). Perceived usefulness, which reflects individuals' beliefs about the benefits and advantages of AI tools, directly influences their acceptance. Educators who view AI tools as beneficial are more likely to integrate them into their teaching practices, highlighting the importance of recognizing the practical advantages of these technologies (Chen et al., 2023). Self-efficacy, or individuals' confidence in their ability to use AI effectively, mediates this relationship (Sadriwala & Sadriwala, 2022). Educators with higher self-efficacy are more likely to see AI tools as applicable, fostering a positive attitude and greater acceptance of these technologies (Ofosu-Ampong et al., 2021). This indirect relationship underscores the need to build educators' confidence to utilize AI tools effectively. Optimizing the interaction between perceived usefulness, self-efficacy, and acceptance is essential for promoting AI adoption in higher education (Alshare & Mousa, 2024). By providing training and support, institutions can enhance educators' skills and confidence, leading to smoother AI integration and maximizing its impact on education (Vedapradha et al., 2024). Based on this, the following hypotheses were proposed for this study:

> *H9: There is a relationship between perceived usefulness and acceptance of artificial intelligence-enabled transformation* among employees *in digital higher education institutions*.
>
> *H10: There is a relationship between perceived usefulness and self-efficacy in the acceptance of artificial intelligence-enabled transformation* among employees *in digital higher education institutions*.
>
> *H11: There is a mediating effect of self-efficacy on the relationship between perceived usefulness and acceptance of artificial intelligence-enabled transformation* among employees *in digital higher education institutions*.

Relationship between Perceived Usefulness, Attitude & Acceptance

The relationship between perceived usefulness and acceptance of AI-driven transformations in higher education, with attitude as a mediator, is crucial for successful AI integration (Rahman & Kodikal, 2024). Perceived usefulness, reflecting beliefs about the benefits of AI tools, directly influences acceptance (Li et al., 2022). Educators who view AI tools as beneficial are more likely to integrate them into their teaching practices, highlighting the importance of recognizing AI's practical advantages. Attitude plays a vital role in this relationship (Malodia et al., 2021). Positive attitudes toward AI bridge perceived usefulness and acceptance, enhancing educators' willingness to adopt these technologies (Alnaser et al., 2023). Optimizing the connection between perceived usefulness, attitude, and acceptance is essential for AI adoption in higher education (Cheng et al., 2022). Institutions can foster a positive attitude by highlighting AI's innovative aspects and investing in training programs, workshops, and upskilling, boosting perceptions of AI's usefulness (Hernandez et al., 2023; Lai et al., 2023). Thus, the following hypotheses were proposed for this study:

> *H12: There is a relationship between perceived usefulness and attitude in the acceptance of artificial intelligence-enabled transformation* among employees *in digital higher education institutions*.

H13: There is a mediating effect of attitude on the relationship between perceived usefulness and acceptance of artificial intelligence-enabled transformation among employees *in digital higher education institutions*.

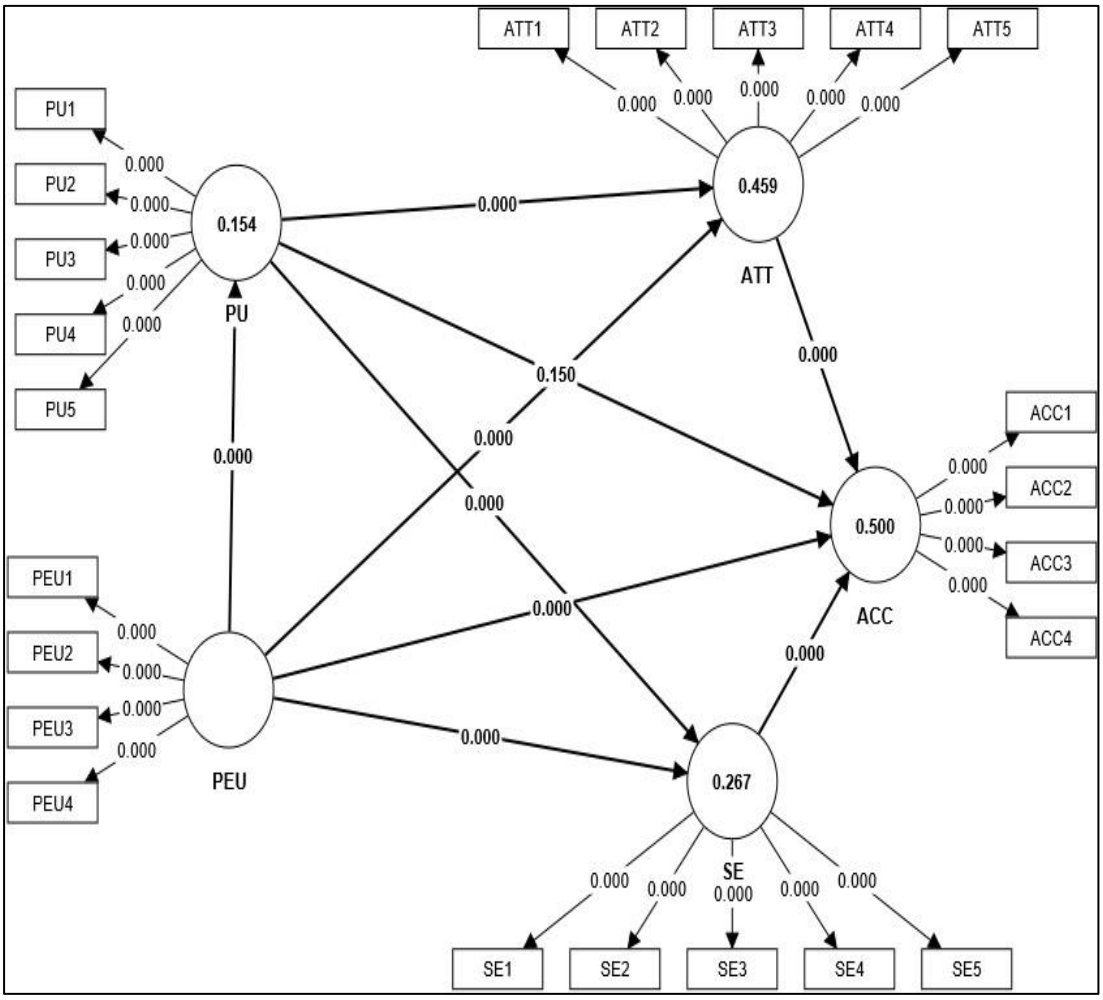


Figure 1 – Research Framework

Note: Perceived Usefulness PEU=Perceived Ease of Use ATT=Attitude Se=Self-Efficacy ACC=Acceptance

METHODOLOGY

This study explored the direct and indirect relationships between perceived usefulness, perceived ease of use, and acceptance, with self-efficacy and attitude mediating among employees in digital higher education institutions. Primary data were meticulously curated through an extensive literature review, ensuring reliable and valid measurements. Survey questionnaires were distributed via email to selected participants using purposive sampling due to the absence of a comprehensive population list. The analysis involved 23 observed variables, including independent variables like perceived usefulness (5 items), perceived ease of use (4 items), and mediators of self-efficacy (5 items) and attitude (5 items), with acceptance as the dependent variable (4 items). Respondents rated each construct using a 5-point Likert scale. Of the 573 surveys distributed, 451 were returned, yielding a 78.7% response rate suitable for

structural equation modeling (SEM). From these, 422 clean responses were analyzed using SmartPLS4, known for its proficiency in SEM (Ringle et al., 2022), enabling rigorous hypothesis testing and multivariate data analysis.

DATA ANALYSIS

Respondents' Profiles

The respondent profile provided valuable insights into the sample demographics. Regarding gender, males represented the majority at 61.4%, while females comprised 38.6%. This gender disparity suggests that the sample may not fully reflect the broader population. Age distribution revealed that the largest group was individuals aged 41 to 50, accounting for 40.8% of respondents. The largest cohorts were those aged 31 to 40 at 23.5% and 51 to 60 at 19.9%. Notably, only 7.1% were under 30, and 8.8% were over 60, indicating a solid emphasis on middle-aged participants, with the 41-50 and 31-40 age groups making up 64.3% of the sample. Regarding professional experience, the largest segment had 11 to 15 years of service (30.3%), followed by those with 16 to 20 years (28.7%) and 6 to 10 years (13.5%). Only 5.9% had fewer than 5 years, and 5% had over 30 years, highlighting a predominance of experienced employees, as 59% possessed between 11 and 20 years of service. Regarding job roles, a significant majority (80.3%) held academic positions, with only 19.7% in non-academic roles, indicating a solid skew towards academic staff. The employer breakdown revealed that 65.6% worked at private institutions, while 34.4% were at public ones, showing a higher representation from the private sector. Remarkably, 98.3% of respondents expressed support for artificial intelligence-enabled transformation, with just 1.7% opposing it, reflecting a solid willingness to endorse such initiatives.

Common Method Bias

Kock (2015) introduced the collinearity test, which was further refined by Kock and Lynn (2012) to assess vertical and horizontal collinearity. Pathological collinearity is indicated when variance inflation factors (VIFs) exceed 3.3, signaling a significant standard method bias (Kock, 2015; Kock & Lynn, 2012). If VIFs fall below this threshold, the model is considered free from common method bias. A full collinearity test was conducted in this study to detect any common method bias. Table 1 presents the VIFs, which were well below the critical value of 3.3 (Kock, 2015; Kock & Lynn, 2012). Specifically, the VIFs ranged from 1.000 to 1.736, averaging 1.368, confirming no significant method bias. These low VIF values indicate that the relationships between latent variables are genuine and not inflated by standard method variance. The results validate the reliability and accuracy of the measures used, ensuring the integrity of the study's findings.

Table 1 – Full Collinearity Test

	ACC	PU	ATT	SE	PEU
ACC		1.775	1.766	1.630	1.539
PU	1.758		1.468	1.631	1.832
ATT	2.034	1.694		1.828	2.121
MS	1.669	1.884	1.578		1.803
PEU	1.450	1.571	1.668	1.741	

Measurement Model

In this study, we adopted the methodology recommended by Hair et al. (2017) to assess each measurement at both first and second-order levels, identifying items with loadings below the 0.7 threshold. The construct reliability and validity analysis showed that all constructs' Average Variance Extracted (AVE) ranged from 0.538 to 0.698, exceeding the 0.5 benchmark, confirming strong convergent validity (Hair et al., 2017). Composite reliability values for all constructs were above 0.7, ranging from 0.786 to 0.864, while Cronbach's alpha values also exceeded 0.7, ranging from 0.784 to 0.855. To ensure discriminant validity, we first evaluated cross-loadings, followed by the use of the Heterotrait-Monotrait (HTMT) ratio, in line with guidelines for Variance-Based Structural Equation Modeling (VB-SEM) (Henseler et al., 2015). The HTMT ratios and confidence intervals confirmed compliance with the 0.9 thresholds, with bias-corrected bootstrap confidence intervals consistently below 1, reinforcing the distinctiveness of the constructs.

Structural Model

In this study, structural model assessment was conducted using the methodology outlined by Hair et al. (2017), examining both path coefficients (β) and coefficients of determination (R^2). The Partial Least Squares (PLS) method was used, with 5000 subsamples, to establish the significance of path coefficients. The results of the hypothesis tests, including path coefficients, t-statistics, p-values, and confidence intervals, are detailed in Table 4, providing insights into the relationships among variables in the structural model. For *H1,* a significant positive relationship between perceived ease of use and acceptance was found (β = 0.226, t = 4.753, p = 0.000), with a 95% confidence interval of 0.130 to 0.314. *H2* confirmed a positive relationship between perceived ease of use and self-efficacy (β = 0.218, t = 4.372, p = 0.000), and *H3* showed a significant relationship between perceived ease of use and perceived usefulness (β = 0.392, t = 7.663, p = 0.000).

H4 indicated a positive relationship between self-efficacy and acceptance (β = 0.380, t = 8.843, p = 0.000). *H5* demonstrated a significant indirect relationship between perceived ease of use and acceptance through self-efficacy (β = 0.083, t = 3.950, p = 0.000). *H6* revealed a significant positive relationship between perceived ease of use and attitude (β = 0.213, t = 4.658, p = 0.000), and *H7* showed that attitude positively influenced acceptance (β = 0.214, t = 3.616, p = 0.000). *H8* indicated an indirect relationship between perceived ease of use and acceptance via attitude (β = 0.046, t = 3.210, p = 0.001). *H9* did not support a significant direct relationship between perceived usefulness and acceptance (β = 0.082, t = 1.440, p = 0.150), leading to its rejection.

H10 showed a significant positive relationship between perceived usefulness and self-efficacy (β = 0.390, t = 7.925, p = 0.000), and *H11* confirmed a significant indirect relationship between perceived usefulness and acceptance through self-efficacy (β = 0.148, t = 5.597, p = 0.000). *H12* demonstrated a significant positive relationship between perceived usefulness and attitude (β = 0.565, t = 14.643, p = 0.000), and *H13* indicated an indirect relationship between perceived usefulness and acceptance via attitude (β = 0.121, t = 3.416, p = 0.001). These results highlight the significant relationships among the study variables, with self-efficacy and attitude mediating key pathways.

Table 2 – Hypotheses Testing Results

Hypotheses	Beta	T-statistics	P-values	Decision
H1: PEU -> ACC	0.226	4.753	0.000	*Accepted*
H2: PEU -> SE	0.218	4.372	0.000	*Accepted*
H3: PEU -> PU	0.392	7.663	0.000	*Accepted*
H4: SE -> ACC	0.380	8.843	0.000	*Accepted*
H5: PEU -> SE -> ACC	0.083	3.950	0.000	*Accepted*
H6: PEU -> ATT	0.213	4.658	0.000	*Accepted*
H7: ATT -> ACC	0.214	3.616	0.000	*Accepted*
H8: PEU -> ATT -> ACC	0.046	3.210	0.001	*Accepted*
H9: PU -> ACC	0.082	1.440	0.150	*Rejected*
H10: PU -> SE	0.390	7.925	0.000	*Accepted*
H11: PU -> SE -> ACC	0.148	5.597	0.000	*Accepted*
H12: PU -> ATT	0.565	14.643	0.000	*Accepted*
H13: PU -> ATT -> ACC	0.121	3.416	0.001	*Accepted*

The model's predictive ability and managerial insights were assessed using the PLS predict method, following Shmueli et al. (2016, 2019). Table 3 presents the results of out-of-sample predictive analysis, where Q^2 values exceeding 0 indicate the model's superior performance compared to naive mean predictions. Additionally, root mean square error (RMSE) values for PLS-SEM predictions outperformed the linear model (LM) benchmark in 11 out of 15 instances, highlighting the predictive strength of the proposed model. Hair et al. (2022) introduced the Cross-Validated Predictive Ability Test (CVPAT) to assess PLS-SEM predictive accuracy. Liengaard et al. (2021) applied CVPAT with PLSpredict analysis, which uses out-of-sample predictions to compute the model's prediction error and average loss value. Two benchmarks were used: indicator averages (IA) and the linear model (LM). For the model to outperform, its average loss value must be lower, resulting in a negative difference compared to the benchmarks. Table 4 confirms that the PLS-SEM model's average loss was lower than the benchmarks, validating its predictive superiority.

Table 3 – PLSpredicts

Indicators	Q^2predict	PLS-RMSE	LM-RMSE	PLS-LM
ACC1	0.138	0.672	0.676	-0.004
ACC2	0.153	0.661	0.652	0.009
ACC3	0.178	0.727	0.731	-0.004
ACC4	0.13	0.752	0.747	0.005
ATT1	0.09	0.704	0.706	-0.002
ATT2	0.066	0.658	0.661	-0.003
ATT3	0.111	0.639	0.643	-0.004
ATT4	0.109	0.699	0.702	-0.003
ATT5	0.103	0.783	0.785	-0.002
PU1	0.059	0.797	0.801	-0.004
PU2	0.101	0.778	0.782	-0.004
PU3	0.137	0.739	0.745	-0.006
PU4	0.089	0.851	0.855	-0.004
PU5	0.036	0.747	0.748	-0.001
SE1	0.101	0.664	0.667	-0.003

SE2	0.054	0.66	0.662	-0.002
SE3	0.064	0.686	0.685	0.001
SE4	0.092	0.684	0.681	0.003
SE5	0.081	0.657	0.663	-0.006

Table 4 – Cross-Validated Predictive Ability Test (CVPAT)

Constructs	Average loss difference	t-value	p-value
ACC	-0.088	4.33	0.000
ATT	-0.052	3.984	0.000
PU	-0.057	3.372	0.001
SE	-0.038	3.202	0.001
Overall	-0.057	4.721	0.000

DISCUSSION

Digital higher education institutions can devise strategies to enhance the acceptance of AI-enabled transformation by focusing on self-efficacy and attitude as mediators, alongside perceived ease of use and usefulness. Research indicates that perceived ease of use and usefulness positively influence AI adoption. To improve perceived ease of use, institutions can offer training programs and online support to help employees become familiar with AI tools, ensuring they are intuitive and accessible. This can include providing user-friendly interfaces, clear instructions, and efficient data handling capabilities (Rahman & Kodikal, 2024). Institutions should also emphasize the perceived usefulness of AI by showcasing its benefits, such as increased efficiency, accuracy, and enhanced decision-making, through demonstrations, workshops, and success stories. Self-efficacy, the belief in one's ability to effectively use AI, is a crucial mediator. Institutions can boost self-efficacy by offering skill development opportunities like mentorship, online tutorials, and hands-on experience with AI tools (Zwacki-Ritcher et al., 2019). Attitude, another vital mediator, can be shaped by fostering a culture of innovation, rewarding AI integration, and providing a supportive environment. By focusing on self-efficacy and attitude, institutions can facilitate the adoption and effective use of AI technologies, ultimately ensuring a successful AI-enabled transformation.

Theoretical Implications

The theoretical insights from the studies reviewed offer significant contributions to understanding artificial intelligence (AI)-enabled transformation acceptance in Higher Education Institutions (HEIs), mainly through the lens of the Technology Acceptance Model (TAM). The focus on perceived usefulness, ease of use, and technological innovativeness align with TAM's key constructs, emphasising their role in predicting technology adoption. These studies deepen our understanding of how these factors interact within the context of higher education, highlighting their influence on AI adoption. The importance of perceived ease of use, reflecting the need for user-friendly interfaces and streamlined processes, is consistent with TAM's assertion that ease of use is a critical factor in technology acceptance. Additionally, including attitude as a mediator enhances the TAM framework by recognising the impact of employees' attitudes on their adoption of AI technologies. This aligns with TAM's emphasis on external variables shaping technology acceptance.

Practical Implications

The practical implications of studies on AI-enabled transformation in Higher Education Institutions (HEIs) provide crucial insights for leaders and policymakers. The research highlights the importance of perceived ease of use, usefulness, and technological innovativeness in driving successful AI adoption. Institutions should offer comprehensive training and online support to improve ease of use, ensuring employees are well-equipped to navigate AI technologies. This includes creating user-friendly interfaces and clear instructions. To emphasize AI's usefulness, institutions should showcase its benefits, such as increased efficiency and accuracy, through demonstrations and real-world success stories. Fostering self-efficacy is also vital, as it directly influences acceptance. Mentorship, hands-on experience, and tutorials can boost confidence in AI tools. Lastly, promoting a culture of innovation and experimentation will help shape a positive attitude towards AI, encouraging adoption. Addressing these factors will enable HEIs to overcome AI adoption challenges and fully harness its transformative potential.

CONCLUSION

The study on AI-enabled transformation acceptance in Higher Education Institutions (HEIs) underscores the importance of perceived ease of use, usefulness, self-efficacy, and attitude in AI adoption. By addressing these through targeted interventions such as training, highlighting AI benefits, building self-efficacy, and fostering a positive attitude, HEIs can improve AI acceptance and utilization. These findings provide critical insights for institutional leaders and policymakers, helping them navigate the challenges and opportunities of integrating AI in higher education. This approach ensures successful AI adoption and supports transformative initiatives within the academic landscape.

REFERENCES

Al-Adwan, A. S., Li, N., Al-Adwan, A., Abbasi, G. A., Albelbisi, N. A., & Habibi, A. (2023). Extending the technology acceptance model (TAM) to Predict University Students' intentions to use metaverse-based learning platforms. *Education and Information Technologies*, 1-33.

AlGerafi, M. A., Zhou, Y., Alfadda, H., & Wijaya, T. T. (2023). It is understanding the factors influencing higher education students' intention to adopt artificial intelligence-based robots. *IEEE Access*.

AlGerafi, M. A., Zhou, Y., Alfadda, H., & Wijaya, T. T. (2023). It is understanding the factors influencing higher education students' intention to adopt artificial intelligence-based robots. *IEEE Access*.

Alkindi, M. Z. H., Hafiz, A. D., Abulibdeh, E., Almurshidi, G., & Abulibdeh, A. (2022). Moderating Effect of Faculty Status in the Relationship between Attitude, Perceived Usefulness, Perceived Ease of Use, Behavioral Intention, Subjective Norms on Mobile Learning Applications. *Journal of Positive School Psychology*, 5359-5379.

Alnaser, F. M., Rahi, S., Alghizzawi, M., & Ngah, A. H. (2023). Does artificial intelligence (AI) boost digital banking user satisfaction? Integration of expectation confirmation model and antecedents of artificial intelligence enabled digital banking. *Heliyon*, *9*(8).

Alshare, K. A., & Mousa, A. A. (2024). Exploring the Acceptance and User Satisfaction of AI-Driven e-Learning Platforms (Blackboard, Moodle, Edmodo, Coursera and edX): *An Integrated Technology Model. Sustainability*, 16(1), 204.

Bansah, A. K., & Darko Agyei, D. (2022). Strategies for Effective Integration of Artificial Intelligence in Higher Education. *Education and Information Technologies*, 27(3), 3451-3466.

Chahal, H., & Rani, A. (2022). Examining the Role of Attitude in the Acceptance of Artificial Intelligence Technologies. Journal of Business Research, 139, 1-10.

Chen, Y., Jiang, Y., & Wen, Q. (2023). Factors influencing students' acceptance of artificial intelligence in higher education. *Information and Knowledge Management*, 13(4), 40-50.

Cheng, X., Su, L., Luo, X., Benitez, J., & Cai, S. (2022). The good, the bad, and the ugly: Impact of analytics and artificial intelligence-enabled personal information collection on privacy and participation in ridesharing. *European Journal of Information Systems*, *31*(3), 339-363.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112, 155–159. doi:10.1037/0033-2909.112.1.155

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.

De Cannière, M.H.; De Pelsmacker, P.; Geuens, M.(2009) Relationship quality and the heory of planned behaviour models of behavioral intentions and purchase behavior. J. Bus. Res., 62, 82–92.

George, B., & Wooden, O. (2023). Managing the strategic transformation of higher education through artificial intelligence. *Administrative Sciences*, *13*(9), 196.

Ghosh, R., & Bhattacharyya, R. (2021). Acceptance of artificial intelligence in higher education: An empirical investigation. *International Journal of Information Management Data Insights*, 1(2), 100021.

Habes, M., Pasha, S. A., Tahat, D. N., Safori, A., Sharadga, T., Bakir, A., & Ajouz, M. (2024). Factors Affecting Artificial Intelligence-Enabled Virtual Assistants Incorporation: A Case Study of the Students of Mass Communication. In *Artificial Intelligence-Augmented Digital Twins: Transforming Industrial Operations for Innovation and Sustainability* (pp. 1-12). Cham: Springer Nature Switzerland.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Thousand Oaks, CA: SAGE.

Hair, J.F., M. Sarstedt, C.M. Ringle, and S.P. Gudergan. (2018). *Advanced issues in partial least squares structural equation modeling.* Thousand Oakes, CA: Sage Publications

Hair, J. F., L.D.S. Gabriel, M., da Silva, D. and Braga Junior, S. (2019). Development and validation of attitudes measurement scales: fundamental and practical aspects, *RAUSP Management Journal*, 54 (4), 490-507. https://doi.org/10.1108/RAUSP-05-2019-0098

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) (3 ed.).* Thousand Oaks, CA: Sage.

Henseler, J., Ringle, C. M., and Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling**,** *Journal of the Academy of Marketing Science*, 43(1): 115-135.

Hernandez, A. A., Sacdalan, R. V., Oller, R. D. R., Alvarez, A. C., & Velasquez, J. E. (2023, December). Predicting the Use Behavior on Conversational Artificial Intelligence enabled Online Shopping in Small and Medium Enterprises: A Structural Equation Modeling Approach. In *2023 IEEE 11th Conference on Systems, Process & Control (ICSPC)* (pp. 270-275). IEEE.

Huang, Z., George, M. M., Tan, Y. R., Natarajan, K., Devasagayam, E., Tay, E., ... & Chow, A. (2023). Are physicians ready for precision antibiotic prescribing? A qualitative analysis of the acceptance of artificial intelligence-enabled clinical decision support systems in India and Singapore. *Journal of Global Antimicrobial Resistance*, *35*, 76-85.

Lai, C. Y., Cheung, K. Y., & Chan, C. S. (2023). Exploring the role of intrinsic motivation in ChatGPT adoption to support active learning: An extension of the technology acceptance model. *Computers and Education: Artificial Intelligence*, *5*, 100178.

Lai, C. Y., Cheung, K. Y., & Chan, C. S. (2023). Exploring the role of intrinsic motivation in ChatGPT adoption to support active learning: An extension of the technology acceptance model. *Computers and Educati*Lalicic, L., & Weismayer, C. (2021). Consumers' reasons and perceived value co-creation of using artificial intelligence-enabled travel service agents. *Journal of Business Research*, *129*, 891-901.

Li, X., Jiang, M. Y. C., Jong, M. S. Y., Zhang, X., & Chai, C. S. (2022). Understanding medical students' perceptions of and behavioral intentions toward learning artificial intelligence: A survey study. *International Journal of Environmental Research and Public Health*, *19*(14), 8733.

Liengaard, B. D., Sharma, P. N., Hult, G. T. M., Jensen, M. B., Sarstedt, M., Hair, J. F., & Ringle, C. M. (2021). Prediction: Coveted, Yet Forsaken? Introducing a Cross-validated Predictive Ability Test in Partial Least Squares Path Modeling. *Decision Sciences*, 52(2), 362-392.

Malodia, S., Islam, N., Kaur, P., & Dhir, A. (2021). Why do people use Artificial Intelligence (AI)-enabled voice assistants?. *IEEE Transactions on Engineering Management*, *71*, 491-505. Ofosu-Ampong, K., Boateng, R., Anning-Dorson, T., & Kolog, E. A. (2021). Artificial intelligence in higher education: Students' acceptance and actual use. *Education and Information Technologies*, 26(6), 7417-7440.

Rahiman, H. U., & Kodikal, R. (2024). Revolutionizing education: Artificial intelligence empowered learning in higher education. *Cogent Education*, *11*(1), 2293431.

Ringle, C.M., and M. Sarstedt. (2016). Gain more insight from your PLS-SEM results: The importance-performance map analysis. *Industrial Management & Data Systems.* 116: 1865–1886.

Ringle, Christian M., Wende, Sven, & Becker, Jan-Michael. (2022). SmartPLS 4. *Oststeinbek*: SmartPLS. Retrieved from https://www.smartpls.com

Rudolph, J., Ismail, F. M. M., & Popenici, S. (2024). Higher education's generative artificial intelligence paradox: The meaning of chatbot mania. *Journal of University Teaching and Learning Practice*, *21*(06).

Sadriwala, M. F., & Sadriwala, K. F. (2022). Perceived Usefulness and Ease of Use of Artificial Intelligence on Marketing Innovation. *International Journal of Information Systems and Social Change* (IJISSC), 13(2), 1-15.

Saqr, R. R., Al-Somali, S. A., & Sarhan, M. Y. (2023). Exploring the Acceptance and User Satisfaction of AI-Driven e-Learning Platforms (Blackboard, Moodle, Edmodo, Coursera and edX): An Integrated Technology Model. *Sustainability*, *16*(1), 204.

Shang Gao, John Krogstie, Keng Siau, (2011)Developing an Instrument to Measure the Adoption of Mobile Services", Mobile Information Systems, 7, Article ID 831018, 23 pages, 2011. https://doi.org/10.1155/2011/831018

Shao, C., Nah, S., Makady, H., & McNealy, J. (2024). Understanding User Attitudes Towards AI-Enabled Technologies: An Integrated Model of Self-Efficacy, TAM, and AI Ethics. *International Journal of Human–Computer Interaction*, 1-13.

Shmueli, G., S. Ray, J.M. Velasquez Estrada, and S.B. Chatla. (2016). The elephant in theroom: predictive performance of PLS models. *Journal of Business Research*, 69: 4552–4564.

Shmueli, G., M. Sarstedt, J.F. Hair, J.-H. Cheah, H. Ting, S. Vaithilingam, and C.M. Ringle.(2019). Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict. *European Journal of Marketing*. 53: 2322–2347.

Son, S.Y.; Moon, J.W.; Yang, K.M.; Kim, S.Y.; Park, C.H.; Hong, E.Y.; Lee, H.J.; Song, D.S.; Park, Y.L.; Jang, M.J.; et al. (2019). Study on the Advancement and Determinants of the Social Acceptability Model of Intelligent Information Technology: Cooperative Study of the Economic and Humanities Society 19-41-02; Korea Information Society Development Institute (KISDI): Chungcheongbuk-do, Korea, Available online: https://www.kisdi.re.kr/report/view.do?key=m2101113024153&arrMasterId=3934560&masterId=3934560& artId=552164

Tan, J., Zhao, Y., & Mei, L. (2023). Exploring the Acceptance of Artificial Intelligence Tools among Educators in Higher Education. International Journal of Educational Technology in Higher Education, 20(1), 1-15.

Vedapradha, R., Hariharan, R., Sudha, E., & Divyashree, V. (2024). Artificial intelligence–talent acquisition in HEIs recruitments. *The International Journal of Information and Learning Technology*, (ahead-of-print).

Yang, H., & Shankar, A. (2023). Artificial intelligence-enabled interactive system modeling for teaching and learning based on cognitive web services. *International Journal of e-Collaboration*, *19*(2), 1-18.

Yu, H., & Nazir, S. (2021). Role of 5G and artificial intelligence for research and transformation of English situational teaching in higher studies. *Mobile Information Systems*, *2021*, 1-16.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 1-27.

BRIDGING THE DIGITAL DIVIDE: GENDER AND AGE DISPARITIES IN AI ADOPTION WITHIN THE FRAMEWORK OF SOCIETY 5.0

Zahari Hamidon[A], Ahmad Izanee Awang[B], Mohd Lokman Abdullah[C]

ABSTRACT

The research investigates the implications of Society 5.0—a vision of a human-centered society integrating advanced technologies such as AI, IoT, and robotics—on education and professional development, focusing on gender, age, and years of service as influential factors in the adoption and proficiency of AI tools.

***Introduction/Objective**: The study aims to explore gender differences in the adoption and effective use of AI tools, the impact of age and years of service on AI tool proficiency, and the influence of personalized AI-generated educational content on lifelong learning and adaptability to new technologies.*

***Methods**: A survey-based quantitative methodology was employed, targeting professionals and learners who engage with AI tools for educational and professional development. The sample comprised 400 participants, stratified by age, gender, and years of service. Descriptive and inferential statistical methods, including correlation were utilized to analyze the data.*

***Results**: The findings revealed that younger individuals tend to use AI tools more frequently than older age groups, with a predominant usage of less than 2 hours per day across all demographics. Gender differences in AI tool adoption and effective use were minimal, with both genders perceiving AI tools as useful and easy to use. Years of service also influenced AI tool proficiency, with those having fewer years of service showing higher engagement. Additionally, a significant positive correlation ($r=0.807$, $p<0.001$) was found between the perceived integration and complexity of AI features in educational tools, indicating that higher integration levels increase perceived complexity.*

***Conclusion**: The study highlights the importance of digital literacy and inclusive strategies to ensure equitable access to AI-driven educational tools, aligning with the goals of Society 5.0. Addressing the usability and accessibility of these tools is crucial to support lifelong learning and technological adaptability. Balancing advanced feature integration with user-friendly design can enhance the usability of AI-driven educational tools, promoting continuous learning and societal well-being.*

INTRODUCTION

[A] *PHD, Centre for Learning Technolgy, Open University Malaysia, Selangor, Malaysia. Email: zahari_hamidon@oum.edu.my Orcid: https://orcid.org/0000-0003-3837-8546*

[B] *Doctor ofEducation, President/Vice Chancellor Open University Malaysia, Selangor, Malaysia. Email: izanee@oum.edu.my Orcid: https://orcid.org/0009-0006-0872-9017*

[C] *MEd, Faculty of Education, Open University Malaysia, Selangor, Malaysia. Email: mohdlokman@oum.edu.my Orcid: https://orcid.org/0000-0001-6664-0260*

Society 5.0 envisions a human-centric society that leverages AI, IoT, and robotics to enhance life quality and solve social issues, merging cyberspace with physical space. This integration seeks to balance economic growth with societal well-being but encounters challenges such as social inequality and digital divides. Developing inclusive, ethical policies is crucial to ensure the universal accessibility of benefits and to promote trust through transparent, accountable AI. Society 5.0 prioritizes higher-order thinking, critical thinking, and problem-solving skills in educational reforms to address technological advancements. Despite AI-driven Communication-as-a-Service (CaaS) boosting infrastructure, privacy issues remain. Promoting a symbiotic relationship between AI and humans is essential, where AI supports rather than replaces human efforts, focusing on creating transparent AI that adheres to human values.

LITERATURE REVIEW

Society 5.0

Society 5.0, as described by Deguchi et al. (2020), aims to create a human-centred society that leverages advanced technologies like AI, IoT, and robotics to resolve social issues and improve life quality by merging cyberspace with physical space, ensuring balanced growth. However, Serpa and Ferreira (2018) warn that without inclusive technology policies, it could exacerbate social inequalities. Similarly, ethical concerns about these technologies are highlighted by Hooker (2019) and Gladden (2019), who emphasize the importance of trust, transparency, and ethical frameworks to manage identity and social structure challenges in a technologically integrated society.

In the educational sector, Mytra et al. (2021) advocate for curriculum reforms to boost critical thinking and problem-solving skills essential for Society 5.0. Meanwhile, Ghosh et al. (2021) discuss how AI-based Communication-as-a-Service (CaaS) can improve network and data management but also recognize the need to address associated ethical and privacy issues. Zhang et al. (2022) suggest fostering a symbiotic human-AI relationship to alleviate job displacement fears and promote transparent and ethical AI support.

Society 5.0 presents a forward-looking vision but is confronted with significant technological, ethical, and educational hurdles. Effective responses require inclusive policies, educational advancements, and ethical governance to realize human-centric goals. This synthesis underscores a complex path towards achieving Society 5.0, calling for a balanced approach to harness technological benefits while addressing potential risks.

Table 1 – Key Features and Indicators of Society 5.0

Feature	Indicator
Human-Centred Society	Quality of Life
Integration of Advanced Technologies	Technological Innovation
Enhanced Quality of Life	Social Challenges
Development of Higher-Order Thinking Skills	Critical Thinking
AI-Based Communication-as-a-Service (CaaS)	Network Management
Human-AI Symbiosis	Collaboration
Trust in Algorithms and Automated Systems	Transparency
Posthumanized Societies	Identity
Inclusive Policies and Frameworks	Equality
Ethical and Privacy Protections	Privacy

Source: Prepared by the authors (2024)

Gender Differences in AI Tool Adoption and Use

The discussion explores gender disparities in using AI tools in education and professional settings, focusing on self-efficacy, perceived usefulness, and ethical concerns. Morris and Venkatesh (2000) identified age as a barrier to technology adoption, stressing the importance of customized training (Personnel Psychology). Bao et al. (2013) found gender differences in technology use, with men showing higher rates of mobile learning technology adoption due to greater computer self-efficacy (Journal of Educational Computing Research). Ofosu-Ampong (2023) noted that women have more concerns about the ethical aspects of AI tools, unlike men who focus on performance (Journal of Digital Art & Humanities). Venkatesh, Morris, and Ackerman (2000) reported that adoption criteria differ by gender: men are driven by tool usefulness, whereas women consider ease of use and social influence (Organizational Behavior and Human Decision Processes). Kausar et al. (2023) highlighted the need for inclusive strategies that cater to age and gender variances in technology adoption using machine learning to detect gender biases in education.

Influence of Age and Years of Service on AI Adoption and Proficiency

Research on the impact of demographic factors like age and years of service on AI tool adoption in professional development reveals varied trends (Meyer, 2011). Meyer notes that younger employees in SMEs tend to embrace new technologies due to their tech familiarity, suggesting that a youthful workforce is essential for technological integration and innovation. Conversely, Niehaves and Plattfaut (2014) identify key influences, such as perceived ease of use and social factors that encourage older adults to adopt technology. Aggarwal (2023) discusses AI's role in lifelong education, focusing on personalized learning that adapts to individual preferences and boosts engagement. Similarly, Akavova, Temirkhanova, and Lorsanova (2023) advocate for AI in crafting tailored educational pathways, while Hashim et al. (2022) note the rise of AI-driven platforms in customizing education. These studies underscore the importance of demographic factors in adopting technology and advocate for AI's potential in education. They stress the need for continuous research and inclusive strategies to maximize AI's educational benefits.

Impact of Personalized AI-Generated Educational Content on Lifelong Learning and Technological Adaptability

This discussion explores enhancing lifelong learning and technological adaptability through personalized AI-generated educational content, highlighting the benefits of adaptive learning systems and AI's role in creating tailored learning pathways. Aggarwal (2023), Hashim et al. (2022), and Akavova et al. (2023) underscore the pivotal role of AI in customizing education to improve engagement, retention, and adaptability to technological changes. For instance, Aggarwal (2023) and Hashim et al. (2022) note that AI-driven systems adapt to individual performance and preferences, enhancing continuous learning and adaptability. Additionally, Hashim et al. (2022) and Akavova et al. (2023) detail how AI facilitates lifelong learning by delivering real-time, personalized feedback essential for developing skills to navigate new technologies. They provide case studies from various settings, including corporate training, where adaptive platforms meet specific learner needs effectively. These studies collectively argue for AI's transformative impact on personalized learning and its crucial role in equipping learners for ongoing technological evolution, ensuring competitiveness in a digital age."

Ethical Concerns and Comfort Levels with AI in Education and Professional Settings

This section discusses the ethical issues and user comfort related to AI in educational and professional environments, emphasizing privacy, bias, accountability, and the impact on education. Holmes et al. (2021) suggest a community framework to tackle ethical concerns, advocating for collaborative guideline development to ensure AI's ethical use. They warn that AI might amplify educational inequalities if based on biased data and call for transparent systems with diverse stakeholder participation to meet all students' needs. Budic (2022) analyzes public attitudes towards AI, identifying a significant disparity between AI awareness and understanding of its ethical implications. The research shows that gaps in public knowledge could hinder AI adoption. Budic highlights the need to improve public understanding of AI, stressing that solving ethical issues such as data privacy and algorithm transparency is key to building trust in AI technologies. Both Holmes et al. (2021) and Budic (2022) underline the importance of ethical considerations in deploying AI in education, pushing for detailed frameworks, inclusive stakeholder engagement, and educational initiatives to manage AI's ethical challenges.

The Role of AI in Facilitating Lifelong Learning and Technological Adaptability

Exploring ethical challenges and user comfort with AI in educational and professional environments, the focus includes privacy, bias, accountability, and AI's educational impact. Holmes et al. (2021) suggest a community framework to manage ethical concerns, advocating for collaboration in crafting guidelines that ensure ethical AI use in education. They warn that AI might exacerbate educational disparities if based on biased data and call for transparent systems with diverse stakeholder involvement for equitable student support. Budic (2022) explores public attitudes towards AI, highlighting a notable gap between AI awareness and understanding of its ethical implications. This lack of knowledge could foster resistance to AI integration. Budic underscores the need for improved public AI education to address ethical issues such as data privacy and algorithmic transparency, which are essential for building public trust in AI technologies. Both Holmes et al. (2021) and Budic (2022) stress the importance of ethical considerations in AI deployment in education, advocating for detailed frameworks, stakeholder engagement, and public education to effectively address AI's ethical complexities.

Background of the Study

Integrating artificial intelligence (AI) in educational and professional environments is key to achieving Society 5.0's goals, which focus on enhancing life quality by merging cyberspace with physical space (Deguchi et al., 2020). However, gender disparities in AI adoption are evident, as men typically show higher computer self-efficacy, while women are concerned about AI ethics and biases (Bao et al., 2013; Ofosu-Ampong, 2023). Inclusive strategies are essential to ensure equitable access to AI tools. Society 5.0 seeks to balance economic growth with societal well-being through advanced technologies, yet risks increasing social inequalities without inclusive policies (Deguchi et al., 2020; Serpa & Ferreira, 2018). AI can tailor education to individual needs, crucial for lifelong learning (Aggarwal, 2023), but must address ethical issues like data privacy and algorithmic bias (Hooker, 2019; Gladden, 2019). Age also affects AI adoption, with older workers finding new technologies daunting and benefiting from specific training programs (Morris & Venkatesh, 2000). Personalized AI-driven learning enhances engagement and educational outcomes (Aggarwal, 2023; Hashim et al., 2022). Transparent, accountable, and inclusive AI systems are vital for public trust and acceptance, addressing privacy and bias issues and supporting informed adoption. This

approach aligns with Society 5.0's equitable distribution of benefits (Budic, 2022; Holmes et al., 2021).

Research Questions (RQ)

RQ1: What are the gender differences in adopting and effectively using AI tools for learning and work?

RQ2: How do age and years of service influence the adoption and proficiency of AI tools in professional development?

RQ3: How do personalized AI-generated educational content impact lifelong learning and adaptability to new technologies?

RQ4: How do personalized AI-generated educational content impact lifelong learning and adaptability to new technologies?

DATA AND METHODOLOGY

Research Method: This study uses a survey-based quantitative approach to systematically collect data and analyze statistical patterns relevant to our research questions, ensuring a robust dataset for analysis.

Research Design: The research design is strategically structured to align with the constructs of each research question, ensuring a focused framework for investigation.

RQ1 assesses gender differences in AI tool adoption and usage, examining constructs like gender, usage frequency, tool types, and perceived effectiveness. Surveys will gather data on how often AI tools are used, which types are preferred, and perceptions of their usefulness and ease, segmented by gender. RQ2 explores how age and years of service influence AI adoption and proficiency, focusing on age, service duration, usage frequency, and self-reported skill levels. The collected data will analyze the variations in AI tool usage and proficiency across different age groups and service lengths. Meanwhile, RQ3 and RQ4 evaluate the effects of personalized AI-generated educational content on lifelong learning and adaptability to new technologies. Key constructs include content type and complexity, engagement, retention, skill development, and ease of adopting new tools. Surveys will measure engagement with AI content, learning retention, skill enhancement, and adaptability to new technologies. Additionally, RQ4 investigates ethical concerns and comfort levels with AI in educational and professional contexts, covering privacy, bias, accountability, and acceptance of AI usage.

This streamlined design ensures that the study comprehensively addresses gender, age, service impacts, and the influence of personalized AI content on learning and adaptability, incorporating ethical considerations of AI use.

Table 2 – Summary table with constructs on the research design

Research Question (RQ)	Keywords	Methodology
RQ1 – What are the gender differences in adopting and effectively using AI tools for learning and work?	Gender, AI tool adoption, Effective use	Surveys designed to capture data on the frequency of AI tool usage, types of tools used, and perceptions of usefulness categorized by gender.

Research Question (RQ)	Keywords	Methodology
RQ2 – How do age and years of service influence the adoption and proficiency of AI tools in professional development?	Age, Years of service, AI tool adoption, Proficiency	Data was collected through surveys to examine the impact of different age groups and years of service on AI tool usage frequency and proficiency levels.
RQ3 – How do personalized AI-generated educational content impact lifelong learning and adaptability to new technologies?	Personalized AI content, Lifelong learning, Adaptability to new technologies	Surveys were employed to gather information on engagement with personalized AI content, learning retention, skill development, and adaptability to new technologies.
RQ4 – How does personalized AI-generated educational content impact lifelong learning and adaptability to new technologies?	Ethical concerns, Comfort levels, AI use in education and professional settings	Survey questions were structured to explore participants' ethical concerns, comfort levels with AI, and frequency and types of AI applications in educational and professional contexts.

Source: Prepared by the authors (2024)

Sampling Frame

The sampling frame includes professionals and learners using AI for education and professional growth. Stratified random sampling ensures diverse demographic representation by age, gender, and years of service. The population consists of active AI tool users, targeting 400 participants for statistical significance. Sampling strata are set by age (17-73 years), gender, and years of service (1-30 years, self-employed, not working).

Data Analysis

The data analysis in this study utilized descriptive statistics to explore key research questions. Mean values, standard deviations, and percentages were employed to summarize demographic characteristics and AI tool usage across various age groups and genders. Additionally, correlation analysis was used to examine relationships between perceived complexity and the integration of AI features in educational tools. The study primarily focused on describing patterns and trends, such as AI tool preferences, usage frequency, and perceived ease of use. This descriptive approach provided clear insights into AI adoption, proficiency, and the role of personalized AI in lifelong learning, aligning with the objectives of Society 5.0.

RESULTS AND DISCUSSION

Demographic

The analysis of population demographics by age and gender shows notable disparities. In the 17-22 age bracket, the population comprises 27 females (6.8%) and 3 males (1.5%), highlighting a female majority. The 23-38 age group, the largest for both genders, consists of 265 females (67.1%) and 120 males (59.1%), indicating female predominance. The 39-54 age group has a more even gender distribution, with 85 females (21.5%) and 66 males (32.5%). The 55-73 age group is nearly balanced, with 15 females (3.8%) and 14 males (6.9%). The sample includes 392 females (99.2%) and 203 males (100%), underscoring a significant gender imbalance, with females nearly doubling males. These results underline the necessity for targeted interventions to correct these demographic imbalances.

Table 3 – Group vs Gender

Age Group	Female		Male	
	N	%	N	%
17 – 22	27	0.068	3	0.015
23 – 38	265	0.671	120	0.591
39 – 54	85	0.215	66	0.325
55 – 73	15	0.038	14	0.069
Total	**392**	**0.992**	**203**	**1**

Source: Prepared by the authors (2024)

The analysis of AI tool preferences across age groups shows clear favourites. Among those aged 17-22, ChatGPT 3.5 is the most popular with 5 users (14.7%), followed by BingAI with 3 users (8.8%), Google Bard with 2 users (5.9%), and ChatGPT 4 Plus with 1 user (2.9%); Mid Journey has no representation. For 23-38-year-olds, ChatGPT 3.5 leads with 160 users (41.6%), followed by Google Bard and ChatGPT 4 Plus with 100 (26.0%) and 60 users (15.6%) respectively, with BingAI and Mid Journey trailing at 21 (5.5%) and 18 users (4.7%). Ages 39-54 see ChatGPT 3.5 dominating with 80 users (52.9%), Google Bard at 40 users (26.5%), and ChatGPT 4 Plus with 30 users (19.8%); BingAI and Mid Journey have 11 (7.3%) and 10 users (6.6%). Across these groups, ChatGPT 3.5 is the preferred tool, especially for those 23-54 years. Google Bard and ChatGPT 4 Plus are also significant; BingAI and Mid Journey have lesser usage, with the latter absent in the youngest demographic. These findings assist AI tool developers and marketers target specific age groups.

Table 4 – AI Tools Usage vs. Age Group

AI Tools	Age Group (years)					
	17 – 22		23 – 38		39 – 54	
	N	%	N	%	N	%
ChatGPT 3.5	5	0.147	160	0.416	80	0.529
Google Bard	2	0.059	100	0.26	40	0.265
BingAI	3	0.088	21	0.055	11	0.073
ChatGPT 4 Plus	1	0.029	60	0.156	30	0.198
Midjourney	0	0	18	0.047	10	0.066

Source: Prepared by the authors (2024)

Technological Proficiency and Adoption

This section investigates RQ1: *What are the gender differences in adopting and using AI tools for learning and work?* It examines the link between age, gender, and the use of AI tools, focusing on usage frequency, tool types, and perceptions of usefulness and ease. The analysis shows usage patterns across age groups, with younger people using AI tools slightly more frequently than older groups, although all age groups seldom use tools for more than 8 hours daily.

Table 5 – Relationship Between Age and Frequency of AI Tool Usage

Age Group	Less than 2 hours per day (%)	3-5 hours per day (%)	More than 8 hours per day (%)
17-22	60.00	20.00	6.67
23-38	69.09	18.18	5.97
39-54	100.00	0.00	0.00
55-73	79.31	10.34	0.00

Source: Prepared by the authors (2024)

Gender and AI Tool Adoption: Analysis of AI tool usage shows patterns varying by gender and age. In the 17-22 age group, 59.26% of females and 66.67% of males use AI tools for under 2 hours daily, with 25.93% of females using them for 3-5 hours. Among ages 23-38, 67.92% of females and 71.67% of males use these tools for less than 2 hours, with about 21.59% using them for 3-5 hours. For those 39-54, 71.76% of females and 80.30% of males engage with AI tools for less than 2 hours, with 20.00% of females and 16.67% of males using them for 3-5 hours. In the 55-73 bracket, 80.00% of females and 78.57% of males use them for under 2 hours, and 13.33% of females and 14.29% of males for 3-5 hours. Generally, usage stays below 2 hours across most groups, with younger individuals slightly more active.

Effective Use: Both genders find AI tools useful, with minimal differences in perceived usefulness. Ease of use is consistent across genders, though younger individuals find AI tools easier to handle than older ones.

Discussion: Research shows that AI tool usage averages less than 2 hours daily across age groups, with younger people slightly more engaged. Gender differences are negligible, as both genders perceive similar usefulness and ease of use. Age impacts AI adoption more than gender. Future studies should examine the specific AI tools each gender uses and their perceived benefits.

Analysis of AI Tool Adoption and Proficiency Based on Years of Service

This section explores RQ2, the effects of age and years of service on AI adoption and proficiency. It analyzes the relationship between service duration and AI tool use in professional environments, focusing on adoption rates and self-reported proficiency, as shown in Table 6.

Table 6 – Impact of Years of Service on AI Tool Adoption and Proficiency

Years of Service (years)	Less than 2 hours per day (%)	3-5 hours per day (%)	More than 8 hours per day (%)
Less than 1	78.46	15.38	0.00
1 – 5	68.35	20.25	0.00
6 – 10	70.00	22.00	0.00
11 – 15	70.59	23.53	0.00
16 – 20	62.50	31.25	0.00
21 – 25	77.14	11.43	0.00
26 – 30	86.96	4.35	0.00
Not working	66.22	28.38	0.00
Self-employed	62.50	25.00	0.00

Source: Prepared by the authors (2024)

In a study of AI tool usage, individuals with 1-5 years of service show that 68.35% use AI tools for under 2 hours daily and 20.25% for 3-5 hours. Similar trends appear in those with 11-15 and 16-20 years of service. In the 21-25 and 26-30 years groups, 77.14% and 86.96% use AI tools for less than 2 hours, respectively. Notably, those with less than a year of service, the unemployed, and the self-employed also predominantly use AI tools for under 2 hours, highlighting a consistent usage pattern across employment statuses. Results show limited daily AI tool usage, higher among newer and self-employed workers. This suggests recent training or greater new technology adaptability. Further studies should examine AI tool types and self-reported proficiency to understand these trends better.

Influence of AI on Lifelong Learning

This section examines RQ3: *How do personalized AI-generated educational content impact lifelong learning and adaptability to new technologies?* It assesses AI-driven tools in education, focusing on their role in fostering lifelong learning and adaptability to new technologies within Society 5.0's context, which integrates AI to improve quality of life through continuous learning.

Table 7 - Frequency of AI Tool Usage

Frequency Category	N	Percentage (%)
Less than 2 hrs per day	424	0.709
3-5 hrs per day	122	0.204
6-8 hrs per day	23	0.0385
More than 8 hrs per day	29	0.0485

Source: Prepared by the authors (2024)

Table 7 highlights the role of personalized AI-generated educational content in lifelong learning and adaptability within Society 5.0. Analyzing respondent data revealed limited use of AI tools, with most (70.9%) using them less than 2 hours daily and a minority (4.85%) exceeding 8 hours. This suggests low engagement with AI-driven educational resources.

Table 8 – Perceived Ease of Use

Ease of Use Rating	Ease of Use 1		Ease of Use 2	
	(N)	(%)	(N)	(%)
(1) Strongly Disagree	14	0.023	9	0.015
(2) Disagree	37	0.062	23	0.039
(3) Neutral	191	0.319	204	0.341
(4) Agree	217	0.363	234	0.391
(5) Strongly Agree	139	0.232	128	0.214

Source: Prepared by the authors (2024)

Table 8 evaluates perceived ease of use in two areas: learning enhancement through personalized AI content (Ease of Use 1) and advantages of technological familiarity (Ease of Use 2). For Ease of Use 1, 59.5% of respondents felt that personalized AI content improves learning experiences. In the case of Ease of Use 2, 60.5% agreed that familiarity with technology enhances AI content benefits. However, around one-third remained neutral, indicating uncertainty about AI's effectiveness in education.

This study emphasizes the importance of personalized AI-generated educational content in achieving Society 5.0's objectives of integrating advanced technologies to enhance the quality of life through continuous learning and adaptability. Many respondents view AI-driven educational tools positively, noting their potential to improve learning experiences, especially for tech-savvy individuals. This highlights the essential role of digital literacy in utilizing AI in education within Society 5.0. Neutral responses suggest better usability and accessibility of these tools to promote an inclusive environment that supports lifelong learning and benefits all in Society 5.0.

In Society 5.0, assessing how AI-generated educational content affects lifelong learning and technology adaptation is crucial. This study analyzed user engagement with AI tools. Findings indicate that 70.9% of users use these tools for less than 2 hours daily, while a mere 4.85% use them for over 8 hours, indicating low overall engagement.

Two perceived ease of use aspects were evaluated: enhanced learning through personalized AI content (Ease of Use 1) and benefits from technology familiarity (Ease of Use

2). For Ease of Use 1, 36.3% of respondents and 23.2% strongly agreed that personalized content improves learning. Similarly, for Ease of Use 2, 39.1% agreed, and 21.4% strongly agreed that technology familiarity increases AI benefits. Despite this, about one-third remained neutral on both aspects, indicating uncertainty about AI in education.

This study emphasizes the alignment of personalized AI-generated educational content with Society 5.0's aim of integrating advanced technologies into everyday life, enhancing quality of life and continuous learning. Most respondents appreciate AI-driven educational tools for improving learning experiences, highlighting the importance of digital literacy in Society 5.0 for maximizing these benefits. Nonetheless, neutral responses suggest enhancing tool usability and accessibility to promote an inclusive environment conducive to lifelong learning, consistent with Society 5.0's vision.

The Impact of Personalized AI-Generated Educational Content on Lifelong Learning and Adaptability to New Technologies

Table 9 – Analysis of Perceived Complexity and Integration of AI Features in Educational Tools

	Perceived Complexity	Perceived Integration
Perceived Complexity	1	0.807 **
Perceived Integration	0.807 **	1

Interpretation of Significance Levels
Significance Levels:
P-Value < 0.001: Highly significant (**)
P-Value < 0.05: Significant (*)
Source: Prepared by the authors (2024)

The analysis showed a strong positive correlation between the perceived complexity and integration of AI features in educational tools, $r(388) = 0.807$, $p < .001$. This finding suggests that more integrated AI features are viewed as more complex. To enhance user adoption, educators and developers should balance feature integration with user-friendly design to reduce perceived complexity and improve the usability of AI-driven tools.

CONCLUSION

This research underscores the need to enhance digital literacy and inclusion within Society 5.0, ensuring equitable access to AI-driven educational tools. It highlights the prevalent use of AI tools among younger individuals compared to older groups, in line with Morris and Venkatesh's (2000) findings on age-related technology adoption. The study observes minimal gender differences in AI tool usage, reflecting Ofosu-Ampong's (2023) findings on uniform perceptions of utility and ease among genders. Additionally, less experienced users show higher AI engagement, supporting Aggarwal's (2023) insights on AI in lifelong learning. The research supports personalized AI education to enhance lifelong learning and adaptability, which is vital for Society 5.0. It notes a significant link between AI integration and feature complexity ($r=0.807$, $p<0.001$), underscoring the necessity of user-friendly designs (Aggarwal, 2023; Hashim et al., 2022). The importance of addressing ethical issues and fostering public trust through transparency is also emphasized for effective AI use in education, as discussed by Holmes et al. (2021) and Budic (2022). This study provides crucial insights into equitable and advanced technology integration in educational and professional contexts.

REFERENCES

Aggarwal, D. (2023). Exploring the scope of artificial intelligence (AI) for lifelong education through personalised & adaptive learning. Journal of Artificial Intelligence, Machine Learning and Neural Network. https://doi.org/10.55529/jaimlnn.41.21.26

Akavova, A., Temirkhanova, Z., & Lorsanova, Z. (2023). Adaptive learning and artificial intelligence in the educational space. E3S Web of Conferences. https://doi.org/10.1051/e3sconf/202345106011

Bao, Y., Xiong, T., Hu, Z., & Kibelloh, M. (2013). Exploring gender differences on general and specific computer self-efficacy in mobile learning adoption. Journal of Educational Computing Research, 49(1), 111-132. https://doi.org/10.2190/EC.49.1.e

Budic, M. (2022). AI and us: Ethical concerns, public knowledge and public attitudes on artificial intelligence. Proceedings of the 2022 AAAI/ACM Conference on AI, Ethics, and Society. https://doi.org/10.1145/3514094.3539518

Deguchi, A., Hirai, C., Matsuoka, H., Nakano, T., Oshima, K., Tai, M., & Tani, S. (2020). What is society 5.0? In Society 5.0 (pp. 1-23). https://doi.org/10.1007/978-981-15-2989-4_1

Ghosh, T., Saha, R., Roy, A., Misra, S., & Raghuwanshi, N. (2021). AI-based communication-as-a-service for network management in society 5.0. IEEE Transactions on Network and Service Management, 18, 4030-4041. https://doi.org/10.1109/tnsm.2021.3119531

Gladden, M. (2019). Who will be the members of society 5.0? Towards an anthropology of technologically posthumanized future societies. Social Sciences, 8(5), 148. https://doi.org/10.3390/SOCSCI8050148

Hashim, S., Omar, M., Jalil, H., & Sharef, N. (2022). Trends on technologies and artificial intelligence in education for personalized learning: Systematic literature review. International Journal of Academic Research in Progressive Education and Development. https://doi.org/10.6007/ijarped/v11-i1/12230

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S., Santos, O., Rodrigo, M., Cukurova, M., Bittencourt, I., & Koedinger, K. (2021). Ethics of AI in education: Towards a community-wide framework. International Journal of Artificial Intelligence in Education, 32, 504-526. https://doi.org/10.1007/s40593-021-00239-1

Hooker, J. (2019). Trusting algorithms in society 5.0. In Optimization in large scale problems (pp. 45-60). https://doi.org/10.1007/978-3-030-28565-4_3

Kausar, G., Saleem, S., Subhan, F., Suud, M., Alam, M., & Uddin, M. (2023). Prediction of gender-biased perceptions of learners and teachers using machine learning. Sustainability. https://doi.org/10.3390/su15076241

Meyer, J. (2011). Workforce age and technology adoption in small and medium-sized service firms. Small Business Economics, 37, 305-324. https://doi.org/10.1007/S11187-009-9246-Y

Morris, M., & Venkatesh, V. (2000). Age differences in technology adoption decisions: Implications for a changing workforce. Personnel Psychology, 53, 375-403. https://doi.org/10.1111/j.1744-6570.2000.tb00206.x

Mytra, P., Wardawaty, W., Akmal, A., Kusnadi, K., & Rahmatullah, R. (2021). Society 5.0 in education: Higher order thinking skills. Proceedings of the 2nd Borobudur International Symposium on Humanities and Social Sciences, BIS-HSS 2020, 18 November 2020, Magelang, Central Java, Indonesia. https://doi.org/10.4108/eai.18-11-2020.2311812

Niehaves, B., & Plattfaut, R. (2014). Internet adoption by the elderly: Employing IS technology acceptance theories for understanding the age-related digital divide. European Journal of Information Systems, 23, 708-726. https://doi.org/10.1057/ejis.2013.19

Ofosu-Ampong, K. (2023). Gender differences in perception of artificial intelligence-based tools. Journal of Digital Art & Humanities, 4(2), 52-56. https://doi.org/10.33847/2712-8149.4.2_6

Serpa, S., & Ferreira, C. (2018). Society 5.0 and social development: Contributions to a discussion. Management and Organizational Studies, 5(4), 26-31. https://doi.org/10.5430/MOS.V5N4P26

Zhang, X., Wei, X., Ou, C., Caron, E., Zhu, H., & Xiong, H. (2022). From human-AI confrontation to human-AI symbiosis in society 5.0: Transformation challenges and mechanisms. IT Professional, 24, 43-51. https://doi.org/10.1109/MITP.2022.3175512

UNDERSTANDING HOUSEHOLD BEHAVIOR AND EFFECTIVE POLICIES FOR WASTE SORTING IN PHETCHABURI PROVINCE, THAILAND

Kamonporn Siripanachai[A], Padcharee Phasuk[B]

ABSTRACT

Waste management requires an increasing budget yearly due to urban expansion, especially in cities with intense tourism industries. If waste management is inefficient, this situation impacts environmental issues and the development of sustainability across various units within the economic structure, this study aims to address this problem. The purpose of the study was to achieve three objectives: (1) to investigate waste separation behaviors at the source in Phetchaburi Province, (2) to examine the factors influencing waste separation at the source in Phetchaburi Province, and (3) to study motivational incentive approaches for the development of waste separation policies. The sampling targeted individuals 18 years old and older using questionnaires. Data collection consisted of a sample size of 400 individuals, who were selected through purposive sampling across eight districts of Phetchaburi. Descriptive statistics and a binary logistic regression model were employed to identify the factors influencing household waste separation behavior and to propose quantifiable motivational policies. The results of this study revealed that the factors influencing waste separation behavior included (1) the quantification of household waste, (2) local waste separation campaign policies, (3) household size, and (4) urban areas. Additionally, it was found that two incentivized policy approaches influenced behavioral changes: incentivizing waste separation by charging a fee based on the amount of waste, which yielded negative responses and offering benefits to households that participated in waste separation, which resulted in positive responses.

Keywords: *Household Waste Sorting, Policies, Logistic Regression, Thailand*

INTRODUCTION

Thailand's expenditure budget for waste disposal and waste management is two billion baht yearly which is increasing and continuing (Thailand Parliamentary Budget Office Office: Yearly report 2560). The proportion of hazardous solid waste from the industry sector and household consumers sectors that considered the changing of hazardous solid waste, Disclosed statistical data in the ratio of industry hazardous waste has no changing in years 2015 and 2016 but on the other side, community hazardous waste household has increased in ratio 2.54% (Office of Natural Resources and Environmental Policy and Planning, 2023)as this problem situation the government must approach in the ratio of solid waste which source from the

[A] *School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: 2656000052@stou.ac.th*
[B] *Assistant Professor, School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: Padcharee.Pha@stou.ac.th*

household, That considers and projects with policy instruments implemented for minimization of waste quantity.

A single policy was unable to meet goal up the long-term goal in waste management strategies. Thailand has implemented long-term goals of (1)setting up a new bio-waste sorting system in collective function as meet up in a ratio of 60% of sorting (2) maintaining sorting the hazardous waste separate from regular solid waste as met up in a ratio of 30% (3) as an origin in community or municipal must separation in regular waste meet up 50% at origin source of waste and(4) not allowancing to authorized for open new dumping waste landfill.(Tsuruyo Funatsu.,2019) Thus, having a waste sorting policy is a reasonable policy within conditions of low risk and low investment for waste minimization quantity management.

Using a waste sorting policy in stated referring to the Pollution Control Department Goverment in THAILAND has disclosed data of waste sorting ratio average of 17% as appeared in 2011-2020. the waste recycling ratio was lower than the management goal which is based on 50% of household waste at the origin. A yearly data in 2020 waste sorting proportion as such as disclosed data was 35% in total. The tangible policy has been operated in the public area only by the Government Official Gazette: Cleaness., (2017) which the Local Authority government must set up 4 garbage bins in four colours supporting waste sorting behaviour and this is a restriction of the Government's rule. Meanwhile in residential areas or household areas was insufficient policy.

The verify waste management in case of household yield by an economic instrument limitiation, therse was current economic instructment as such as waste collection fee or "*khar ka yar"* has being forced indirectly overall by flatted rate formular structure of fees,By fee rate 30-40Baht./600 Litres of waste/1 househouse unit /month (Royal Gazette: Cleanness, 2546) the dynamic of consume behavior has been change. Thus, the law development as following consume behavior was adjusting waste collection fee in the new ceiling fee rate structure in the same fomular rate by 150Baht./600Litres/1 househouse unit /month.(Royal Gazette: Cleanness, 2560)the increasing fee has not reflected and not coverage yearly expenditure which was the study from Chiemchaisri Chart, Visvanathan Chettiyapan & Labayen J. Jeanger., (2006) have studied and reported that the overall waste collection fee was able absorbed only 30-35% of overall cost of waste management in Thailand-This was the condition of indirectly policy for increase fee was not sufficient for shaped the ratio into waste sorting in household by waste minimization in overall goal,the key issue of ability in waste sorting at source was important before disposal step in any disposal technogies that Jormaod Sawangwong ,(2553) has been studied.

Hence, waste sorting policy is necessarry in Thailand, the location of province that has a variety economic activities- waste separation ratio that appearing was able explain economic activities in household living in percentage by weight of waste that express in economic activities. (Phirayut Wannaphut, 2556)

While cosidering in study area, the west of Thailand has been facing for accumulative accrual waste quantities referred to Pollution Control Department, annual report (2565),Phetchaburi Province was loacted in west, which was engaged revenue from mainland touristy activity,beach touristy and ecological touristy as such as Kaeng Krachan Natural Park, also which has been promoting in livability town by Tourism Authority of Thailand. The household waste components has been express town, community, economic activity - touristy town, agricultural town and bordered town location, this study was approach and analyzed in Phetchaburi the study purpose in three objectives:

(1) to investigate waste separation behaviors at the source in Phetchaburi Province.

(2) to examine the factors influencing waste separation at the source in Phetchaburi Province.

(3) to study motivational incentive approaches for the development of waste separation policies.

LITERATURE REVIEW

This article presents a study in term of economic behavior. These imply the satify of household segments of the community, it has impled in consumer behavior, in household, community, town, province and society. Approaching two economic transactions between service provider and household who involved incondition of service paying. A literature review are implicitly the reationship in behavioral equation within doing waste sorting or not doing waste sorting with policy instructments as social has being put.There were two main issues of literature:

A. Behavioral consume equation and implicitly

Firstly, the economic literature addressed in consumer decision was present in the utility maximization which has been expand from the utility theory.In term of specification on **implicitly** condition by the ordinal preference was able to apply to this implicatation in phenomenon data viewing and reflect into two economic transactions between service provider and household. The service provider was local government and household was end of users who receiving waste collection service, these two economic transactions which forced into probability in waste sorting behavior and policies were aimed to area minimization in waste.Meanwhile, the relation between service provider and household in term of enforceable policy also include in main waste minimization criteria for socity.

Behavior is rooted in society and culture,(John, 2012) in 1940 Karl polanyi explained referring to Alfred Marshall, 1890 that individual people make decision in diffrence consume choice was a frame in consume decsion for evaluation the satify of services and risk with incertainly based on the minimization of risk as will obtain satisfy and happiness as following this equation, $W = f(U_1, U_2, U_3 \ldots, U_n)$

The preference consume and utility equation, $U(X_1, X_2)=X_1^{\alpha}, X_2^{1-\alpha}, \alpha > 0$, which explained by Bergemann Dirk (2012) in Utility Maximization that able to consider based on(1)Preference, (2)Ordinal and cardinal utility(3)Indifference curved,(4)Total Utility, Marginal Utility.The accurancy of numerical as specific is difficult to use and express in consumption decision.

B. Society Policy Instructment

Secondly, the service provider is government who used the existing waste sorting policy and aim to minimized quantity of waste as achievement social goal, the waste separation is a goal in society for waste management. The motivational incentive policy is alternative key for driven. Yew-Kwang Ng (2003)explained in subject From preference to happiness: Towards a more complete welfare economics that Cezary Kaliszyk and Julian Parsert(2018) studied in title: Formal Microeconomic Foundations and the First Welfare Theorem. Approaching in social, political and economic changes which were getting what you want, getting something useful that influences living. By useing Isabelle/HOL which this model was pure exchange economy and usig Arrow-Debreu Model for approach the collaborative ownership approach in the economic system, including production facilities, collecting from economic literature in term of equality priciple and neutrally also implied ideal foundation for presentation as

extended micro economic and game theory integrated with other theory as proved the truth, it was proved in the First Welfare Theorem by mathematical in logical refered to "invisible hand and states" as belonging to Adam Smith's as it was self-interested persons in Social and logical-resonable thinking's people in social for allocation resourse, products, services with the efficiency.By math proving the reation of mathmathical term in 1818 lines of proofs include 98 lemmas and theorems the summarry from Cezary Kaliszyk and Julian Parsert(2018)were fundamentals in the preference relationship and the utility functions and specific proportions of preferences must be developed provider framework in concept(implicit) equality.These fundamentals result is a general way to more enable economic theory model and game theory to be constructed to the relationship.(Cezary Kaliszyk and Julian Parsert,2018)

Behavior theory is occurred from observation how the end of consumers has obtained satisfying from government's service which is able to express phenomenon of society. Behavioral equation in mathematical based on the derivative factors as related in term of independent factor and dependent factor as in binary logistic regression, while comparative factors, implication proportion of behavior, by doing waste sorting or not doing waste sorting have been effected from logistic regression model.

The indication into society policy instructment in condition of economics literature eyes' approach within, "Household Characteristics" as related in the effort for waste minimization is a must to consider according to household income and household size are the factors to be considered in waste management which referred from Afroz et al., (2010) the socio-economic status as condition of population changed, personal income changed and city size e.g. urban or rural was also consideration for quantities of waste(Cheremisinoff, 2003) in a projection of city size in Veniamin has found that rural area was significant factor for waste sorting behavior. These was analyed by Nguyen .,T. T & Watanabe.T (2019) in objective study were finding out the behavior of waste sorting in 298 rural area sampling by finding the performance between sample groups with independent variable values t-test and the idea of waste sorting behavior using; Theory of Planned Behavior to find the differences in perceived names, economic and social factors, Getting resulted were Livestock owners had more positive attitudes towards waste separation, were more concerned about personal norms, were more aware of the negative impacts of waste, had better perceptions of promoting waste separation, and were more effective at waste separation than non-livestock owners.also the finding results from Multiple logistic model was rural area was significant factor and powerful factor which was affecting habits for local people's waste sorting.Indicating that the garden was convenient place for waste sorting and disposal. Other factors that determine waste sorting efficiency by waste management in trusty, in capabilities and local policies-the location /size of location was within analyzed.

While consider in household characteristics or household behavior, in view of sorting policy has linking with household behavior-thought utilization more than four regions as linking with waste sorting policy. In Korea, Seung-Joon Yoon (2020) explained ratio of the three implement method as used in Korea social were Dumping or Landfill, Incinerator and separation waste sorting for recycling which the separation in waste is higher growth ratio, which was reducing of house waste in Korea by analyzed in disclosed data in 1995-2017.

In China waste sorting policy is core policy for sustainable and to be neutral carbon gas country with aimed to reduce waste quantities as according to Tian et al., (2022) studied the implementation of policies can increase public waste sorting behavior: A comparison between counties with and without waste sorting policies in China. By using online qantionare data in 4,699 sampling, in term of the impact on waste sorting behavior that was promoting the theory of plan behavior linking literature in actural policy situation with psychological and behavioral variables, aiming to examine the current status of waste sorting behavior among Chinese's

people with diverse demographic backgrounds. In 4,699 Sampling had showed the good perceptions in terms of knowledge, intention and behavior in waste separation Even though the Chinese people have high intentions in waste separation, the results of the Wilcoxon model compared in sampling groups that studied in area within the waste separation policy as actually participated for waste separation behavior, which finding the results were more than the people in the without area of waste separation policy. And the proposed effects of knowledge and intention were proven to provide valuable empirical information, policy maker and stakeholders from various perspective of policy implementation. Therefore, waste sorting policy was standing in pilot policy status it was not coverage in all provinces.

Meanwhile, in Italy the participation into sorting policy which involved collecting waste systems as its was maintaining in Italy by door to door collecting sorting system was ineffectiveness for decreased waste from household, the Itlaian's participating users showing the reflection of waste collect service system specific for Italian ‘s characteristics. The service time frame of the door-to door waste collecting was supposed to revamp, an adequately collect waste sorted more motivated to waste fractions upon Italian’s people was receiving information about the subsequent environmental benefits and outcomes of the fractions that analyzed by Laurieri et al., (2020). Analyzed in Japanese policy regarding to waste separation and recycle policy Terazore et al., (2005) explained “Recycling in Japan's sound-material-cycle society policy” has getting a couple of results, the one was waste collection as following the sort policy would be done by official government /material collectors from government organizations, and the collected materials after the local government officials have been collected and transported its. These situation Japanese’s people who collected waste/material in informally, it was emphasized that as long as the economic value of the recycled materials/waste was certain, it was going to find the separation waste/material collectors was coming from informal groups in the social system. Terazore et al., (2005) addition explained in an environmental relationships which was considered to be a more difficult concept to observe than economic growth and sulfur oxides emissions that the supporting evidance reffered to Harashima and Shimazaki (2002); Selden and Song (1994)and Matsuoka, and Kochi (1998), who suggested that the Kuznet’s curve concept was unable applied to consider in waste amount. There was evidence that high waste volumes are associated with high GDP. The graph shows a flat line that is far from the Kuznet’s curve. Therefore, Terazore et al., (2005) have given that The application of the Kuznet’s curve thorey was unable be applied for considering in the amount of waste.

Zaikova et al., (2022) have studied in Russia and Finland the study approached in factors influencing household waste sorting behavior, that analysed sampling (who received and accepted waste sorting program with getting the returning benifit who have been influencd for material recycleing. A collaborative review approach in which the waste collection service fees, which charge to household unit was based on the environmental principle of joint responsibility (Ownership based), which was consistent with the educational approaching found in the Finland.

As recognized, waste sorting policy at Phetchaburi has no preferentially policy as specification method. It was using indirectly policy from promoting campaign from waste sorting with free style policy design in Phetchaburi Authority, amidst as situation only providing four color bins in the public area was not sufficient for household. In Phetchaburi province, an existing policy as reference in disclosed report in 2015-2018 was been address to asking in questionnaire which these indirectly policy was enforce in previous. Knowing existing policies determinants factors that involved is a must to consider. Its towards for analyzed reaction waste separation behaviors proportion and influenced factors include policies instruments as caused for changing behavior opportunity of household, community, town and province.

DATA AND METHODOLOGY

This artical based on quantitative research aimed to investigate numerical information from questionnaires data, these study has analyzed in two mainly in descriptive statistic and a binary logistic regression analyzed for behaviors, determinants of factor, analyzed with addition in motivated incentive policy of wastte sorting at residential/or household.

Research Methodology

Observation data from 400 respondents has been imply in matmathical vectors function of behaviors to do/or not do waste sorting indicated and projection as follows in Figure1.

The Questionnaire components were three section:(a)Asking into in general individual disclosed data, age, career, education, main income, supplimentary income, Debt, Residential owning. Section:(b) Asking involved of Waste Sorting Behavior, Do/Not Do waste sorting, frequencty of sorting, time of sorting, income from selling waste, waste type of sorting, recalling in waste quantity of making separation. Section:(c) Existing waste sorting policies , how respondents attended or participaled and motivation incentived policies as design for asking base on literature review:

• **Discount Fee**, by keeping same fee rate and give the discount rate when doing Bio-waste sorting, referred to European Enviroment Bureau,(2020)

• **Pay As Actural**, by keeping same fee and doing waste sorting. Referred to pay as you throw rate structure policy Canterbury Janice L.,(1994).and Ukkonen & Sahimaa, (2021)

• **Obtain Alternative Benifit**, sorting in waste. Refer to economic policy literature review when end user has being feel to get a tangible benifit returing to end users when doing waste sorting. These motivation referred to Ola Eriksson.,2014

• **Refund Revenue Tax**, sorting in waste. These motivation refer to fiscal policy instrument by Ekins et al.(2023)

Population and Area Based Sampling

The population as disclosed were quantities 485,191 individuals (Thailand Interior data goverment, 2562) Using the propulation statistic table of Krejcie&Morgan (1970)at significance level of 0.05 (Alpha, α= 0.05) The purposing sampling based on 18 years old and older, with area based sampling into 8 districts have been distributed in Phetchaburi - Covering a small town size as called "*Aor Bor Tor*" and Bigger town size as called "*Thead Sa Barn Meaung*" include "*Thead Sa Barn Thambon"*(Meaung Municipal and sub-district municipal) as follows in Figure 2.

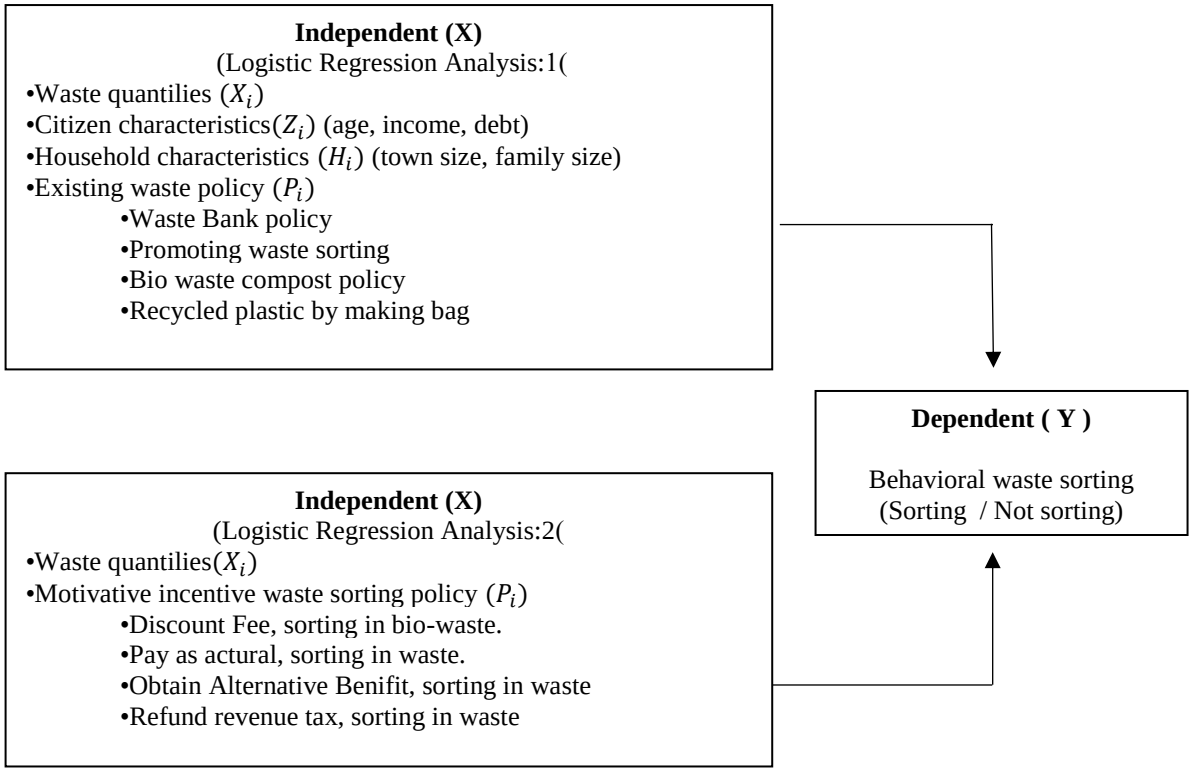


Figure 1 – Implied reationship between behavioral and projections factors

Districts	Populations	Sampling Ratio	Namber of Sampling
Meaung	123,146	25.38	102
Cha-Am	81,205	16.74	67
ThaYang	86,419	17.81	72
Baan-Lat	52,051	10.73	43
Baan-laem	53,685	11.06	44
Khao-Yoi	39,020	8.04	32
Kaengkrachan	33,416	6.89	27
NongYaPlong	16,249	3.35	13
8 Districts in totally	485,191	100.00	400

Source: Interior Goverments Data.)2562)

Figure 2 – Distributed Sampling Size indicated in 8 Districts of Phetchaburi province

The dummy code has been settled in condition for finding the numerical phenomenon from questionnaire data from sampling which implied behavioral equation in the first logistic regression analysed as following :

$$ln(\frac{Y_i}{1-Y_i}) = \alpha_o + \sum_{i=1}^{n} \eta_i X_i + \sum_{i=1}^{n} \omega_i Z_i + \sum_{i=1}^{n} \phi_i H_i + \sum_{i=1}^{n} \delta_i P_i + \varepsilon_i$$

In condition:

Y_i : behaviors of doing waste sorting of sampling

when i = 1 Doing waste sorting behavior
i = 0 Not doing waste sorting behavior

X_i : vectors of household quantitys *)Normaliation data in range 0 to1)*

Z_i : vectors of citizens

when i = 1 Ages of sampling (year)
i = 2 Income by monthly of sampling (Thai Baht)
i = 3 Debt by monthly of sampling (Thai Baht)

H_i : vectors of household characteristics

when i = 1 Family Menbers Quantity (individual)
i = 2 Size of Authorized town as located(Small and Bigger town)

P_i : vectors of existing household waste sorting policy

when i = 1 Waste Bank policy
i = 2 Promoting waste sorting
i = 3 Bio waste compost policy
i = 4 Recycle plastic by making bag

η_i unknow parameter vectors of vector X_i
ω_i unknow parameter vectors of vector Z_i
ϕ_i unknow parameter vectors of vector H_i
δ_i unknow parameter vectors of vector P_i
α_o constant term
ε_i error term

The Second logistic regression model analysis as following :

$$ln(\frac{Y_i}{1-Y_i}) = \alpha_o + \sum_{i=1}^{n} \eta_i X_i + \sum_{i=1}^{n} \delta_i P_i + \varepsilon_i$$

In condition:

Y_i : behaviors of doing waste sorting of sampling

when i = 1 Doing waste sorting behavior
i = 0 Not doing waste sorting behavior

X_i : vectors of household quantitys *)Normaliation data in range 0 to1)*

P_i : vectors of motivated incentive policy for waste sorting

when i = 1 Discount Fee, sorting in bio-waste.
i = 2 Pay as actural, sorting in waste.
i = 3 Obtain Alternative Benifit, sorting in waste
i = 4 Refund revenue tax, sorting in waste

η_i unknow parameter vectors of vector X_i
δ_i unknow parameter vectors of vector P_i
α_o constant term
ε_i error term

RESULTS AND DISCUSSION

These result have being displayed in descriptive statistics and binary logistic regression model the investigation in sorting behaviors at Phetchaburi Province, finding out influenced

factors in waste sorting behavior and waste separation policies as purposing by motivational incentive as results;

1. Waste Sorting Behavior

The majority sample was female average age of 41 years old, employed as labor, holding a bachelor's degrees, having married, with an average household size of 4 members, residencing in rural area("*Aor Bor Tor*") with owning residence, an average main and supplementary incomes less than 10,000 THB/month, in debt 3,509.08THB/month in average.
(see in Table1) the 81.0% of sampling have been doing waste sorting at household once a day, during time 16:00 to 18:00, under aiming to increase income, which was selling waste separation(recycle material) per time not exceeding 100 THB. In 28.3 % of sampling doing waste sorting by increasing income reason, in 23.2% by house cleanness reason and 21.5% doing waste sorting by save the earth reason.

Authorited Town Type as located in "*Aor Bor Tor"* Type (small authority town) as following see in Table 2. Plastic bottles were the most commonly separated recyclable material. However, when compared to the overall volume of household waste, glass or glass bottles had the highest proportion of separation, followed by electronic waste. As according to data in Table 3 the descriptive statistical present the behavior of respondents in participated of existing that 86.3% participated in promoting of waste sorting policy, 75.5% in Bio-waste making compost follow by 65.5% in waste bank policy and the lowest in 54.0% in Recycle plastic by making bag, while tested the responding from four motivative incentive approach policy the highest proportion in 39.8% were participated in getting alternative return when doing waste separation at household, 28.0% in refundable income tax when doing recycle following in 22.8% were participated from Discount waste fee rate from Biowaste sorting and the last was the Pay as actual, when doing waste sorting. In 19.0% of totally respondents.

2. Determinants and influenced factor of waste Sorting Behavior

Model in the first and the second analyzed following in logistic regression model statistic conditions with chi-square level (x^2) in 0.05, it also deductive quantitative research which is probability level must less than chi-square in 0.05, also the index of goodness of fit of the models were not over in range 0.50 of the goodness of fit the model (as showing in Pseudo R-Square in 56.27% in table 4, and table 5)with the model accuracy is meted up 93.75%, and over 93.50% it were able to interpretated that,

In the first analyzed into logistic regression model that comparative and viewing the reation of data phanorama of 400 sampling its has been found in examined the influenced factors of waste separation at the source in Phetchaburi Province ,there were four main factors were significant (1)factor of waste quantities, (2) factor of waste sorting promoting which existing used (3)family member or household size and (4) big town or urban , all these were influencing factors as relationship with waste sorting behavior. (see in data Table 4)

3. Motivated incentive policies as influenced in waste sorting behavior

In the second logistic regression analysis has found a couple motivation incentive was significant, the one was Paying as actual or charging fees, another is alternative benefits offering. Both of its have being in difference effective direction.

Besides, policy by charging fees based on the waste amount has been influenced behavioral changes in yielding the negative responses and policy by respondents getting alternative benefits when participating in waste separation was yielding the positive responses.

DISCUSSION

These study was able to explained the phenomena in four influenced factors which being effective with sorting behavior: (1) waste quantities(2)family member quantities (3)urban area or big town and (4) promoting in waste sorting policy all these factors have caused by lower quantities of family member will higher trend for waste sorting in comparatively, as such as analyzed result from Afroz et al., (2010) in Diaga city, Pakistan which was specified that the sizing of family has effected in waste quantities changing and household waste managerial, beside residential in rural or in the small town shall be higher trend of waste sorting behavior by compared consideration which Nguyen & Watanabe (2019) has been presenting in same direction was in rural area the sorting behavior was significant to do the waste sorting because of population living in rural was livestock career-the benefit from doing waste sorting in often feed to animals. Furthermore, Local administrative organizations in rural area as located in Phetchaburi Province (as called "*Aor Bor Tor"*)was able to management in waste quantities that handling and waste managerial in control not exceed power, these area size factor also according in the same evidence from Cheremisinoff (2003) and Liu et al., (2022) have studied in united stated of America and China have found that living area in the urban living condition will higher trend in regular waste quantity than in the rural living condition due to residential concentrative base. Consuming in household was base in concentration.

These results have not involved in income and debt of household, the interpretations that income and debt were unable to influence with waste sorting behavior which were pin the point that household economics norm are not involve factor in sorting behavior, these specific that sorting behavior was might get externalities effect e.g. policy, enviromential regulations, opportunity cost of household that enforcement within sorting behavior that following as the resulted from Elrabaya et al., (2022) and Watchira Sitthibort(2553) both researchers found that was management policy and engatement of enviromential rules will impact with household waste management were signnificants.

The Indicatd into motivative incentive policy were founding two direction of motivative incentive policy from "Pay as actural quantities" or pay as you thrown motivative policy was able to change the probability of waste sorting behavior.in negative direction was signnificant, In opposition, policy from alternative benefit returning was able to change the probability of waste sorting behavior.in positive direction was signnificant. Both motivative incentive both positive and negetive have being settled in the response of social welfare refer to Welfare Economics Theorem by Kaliszyk & Parsert.,(2018) analyzed and specified that The effective policies must be based on equality or equity with fairness for all indivudual groups of living people in society .It is a must be based on increasing in equal satisfaction (Indifferent Curve) of society and the exchange of resources in society (Endowment in policy) whithout other living people in society will not reduced in equal satisfaction as reffered in Pareto Efficient policy

In this amist, service recipients will observe behavior that they are satisfied with the state service , stated policy from the utility, which is an explanation of the social phenomenon by Yew-Kwang Ng., (2003) and Zaikova et al., (2022) supporting studied in the same direction, it was found from the influenced factors of the behavior in household waste separation. The case study of Russia and Finland confirmed that the empirical results in the sample households

were more likely to separate waste when under conditions that they received some benefits from that separation.

SUGGESTION

(1) Behavior of waste sorting was related in local governments policies which was maintain the promoting into household waste separation, as these relationship was able to change the probability of behavior in the positive, hence the local government is going to extend the promoting into waste separation with optimization and in continually, while design the policy was raised the conditions of household characteristic as point it out from the members family size, criteria of town in rural or urban integrated making the policies in Phetchaburi province.

(2) Policy instruments are a necessary with location of implemented policy and these policies are sufficient of phenomena of waste sorting behavior, even though method in improve or motivative incentive policy by using policy is need for managerial in household waste by no stopping, because of waste sorting policy is the effortless policy.

If government has not pushing any policy in current a phenomena of waste situation in community, town and social is worse than currently.

The motivative Incentive policy and pay as actual policy (or pay as you thrown policy) both of policies were a difference effective with the relationship of sorting behavior both positive and negative direction. Meanwhile, ratio of waste separation in condition was related in household user/or end of user which was the probability into differentiation with waste sorting behavior in Phetchaburi Province from incentive of waste sorting policy.

Using incentives benefits policy to perform waste separation behavior by undering same rule and fairness condition as related in household Characteristics will lead an incentively benefit methods was sufficients from service recipients that implication that government *understand household Characteristics and sorting characteristics.*

Thus, Local administrative organizations is going to improve and extend develope idea of waste sorting under the rule and condiotion of end user must get the returen benefit when separation wast at their house with the optimization and approaching for increse probability of sorting behavior.

CONCLUSION

Service providers is local administrative organizations as located in Phetchaburi has being understand the household user/or end of service user as expression all economic activities by main pointing of household characteristic into family size, location based in term of urban or rural are a mainly consider while design and implement waste sorting policy and the evidence is support the positive waste sort behavior is the household user is feeling norm in get benefit return when doing waste sorting as such as understand and making waste sorting.

To be aim to increasing ratio of waste separation is supposing to using incentives benefits policy to perform waste separation behavior in condition of fairness with optimization referring base on location and family size.

REFERENCES

Alessandra Tafuro, Giuseppe Dammacco, Paolo Esposito and Giovanni Mastroleo (2022). *Rethinking performance measurement models using a fuzzy logic system approach: a performative exploration on ownership in waste management. Socio-Economic Planning Sciences.* https://doi.org/10.1016/j.seps.2021.101092

Atsushi Terazono, Yuichi Moriguchi, Yuko Sato Yamamoto, Shin-ichi Sakai, Bulent Inanc, Jianxin Yang, Stephen Siu, Ashok V. Shekdar, Dong-Hoon Lee, Azni B Idris, Albert A. Magalang, Genandrialine L Peralta, Chun-Chao Lin, Pireeyutma Vanapruk and Thumrongrut Muagcharoen. (2005). *Special Feature on the Environmentally Sustainable City, Waste Management and Recycling in Asia.* Vol 5, Page. 477-498. The Institute for Global Environmental Strategies. https://www.iges.or.jp/en/pub/special-feature-environmentally-sustainable-5/en

Anna Zaikova, Ivan Deviatkin, Jouni Havukainen, Mika Horttanaien, Thomas Fruergard Astrup, Minna Saunila and Ari Happonen (2022) *Factors Influencing Household Waste Separation Behavior: Cases of Russia and Finland.*, MDPI, Basel, Switzerland. https://doi.org/10.3390/recycling7040052

Bergemann Dirk. (2012). Intermediate Microeconomics**.** [Online Lecture-Notes]. https://bpb-us-.wpmucdn.com/campuspress.yale.edu/dist/3/352/files/2012/04/Complete-Lecture-Notes.pdf

Canterbury Janice L. (1994) .*Pay as you throw; Lesson Learned about unit price.* United States Environmental of protection. U.S. EPA Office of Solid Waste. https://archive.epa.gov/wastes/conserve/tools/payt/web/pdf/payasyou.pdf

Cheremisinoff, N. P. (2003). *Handbook of Solid Waste Management and Waste Minimization Technologies.*, Elsevier Science: Butterworth Heinemann, USA

Chiemchaisri Chart, Visvanathan Chettiyappan and Labayen J. Jeanger., (2006). *Municipal solid waste management in Thailand and disposal emission Inventory.*, Environmental Monitoring and Assets. https://DOI:10.1007/s10661-007- 9707-1

Comhshaol,Pobal agus Rialtas Aitiuil. (2016). Pay by weight know your waste, control your cost. Ireland., [online] https://www.limerick.ie/sites/default/files/media/documents/2017-05/pay_by_weight_information_leaflet.pdf

Deaton Angus and Muellbauer John. (1980). *Economics and consumer behavior*, Cambridge University Press, United States of America

Doan Nainggolan, Anders Branth Pedersen, Sinne Smed, Kahsay Haile Zemo, Berit Hasler and Mette Termansen. (2019) *Consumers in a Circular Economy: Economic Analysis of Household Waste Sorting Behaviour.* https://doi.org/10.1016/j.ecolecon.2019.106402

Elrabaya D., and Marchenko V., (2022), The influence of organizational and economic methods of household waste management on volumes and structure of its formation: The experience of Netherlands., Eastern-European Journal of Enterprise Technologies. DOI: https://10.15587/1729-4061.2022.259721

European Enviroment Bureau., (2020) https://eeb.org/wp-content/uploads/2020/03/Separate-collection-factsheet.pdf

Ekins Paul, Baek Seungju, Kacaribu Febrio Nathan, and Halimahtussadiah Alin., (2023) Fiscal policy Instruments and Green Development. Asian Development Bank Institute. https://doi.org/10.56506/EZUA1622

Goodstein Eban S and Polasky Stephen., (2014). *ECONOMICS AND THE ENVIRONMENT*. John Wiley& Son Inc., Edwards Brothers Malloy, United Stated of America

Hathairat Seandang and Chuenruthai Kanchanachitra. (2550). Urban and garbage, Journal of Population and Society, Mahidol University, 2007, pp. 138-154. https://ipsr.mahidol.ac.th/wp-content/uploads/2022/03/Report-File-331.pdf

Jianchi Tian, Yuanchao Gong, Yong Li, Xuefeng Cheng, Linxiu Zhang and Yan Sun. (2022). *Can policy implementation increase public waste sorting behavior? The comparison between regions with and without waste sorting policy implementation in China*., ScienceDirect. https://doi.org/10.1016/j.jclepro.2022.132401

Jormaord Sawangwong, (2553). Energy and economic analysis including environmental externalities of municipal solid waste power plant. https://cmudc.library.cmu.ac.th/frontend/Info/item/dc:113360

Kaliszyk Cezary & Parsert Julian. (2018). *Formal Microeconomics Foundations and the First Welfare Theorem.* https://dl.acm.org/doi/pdf/10.1145/3167100

Kishtainy N., Georage A., Farndon J, Kennedy F. Meadway J., Christopher W. and Weeks M. (2012). *The economics book.* Dorling Kindersley Limited, London.

Krejcie, R.T., & Morgan, D.W.(1970). Determining sample size for research activities. Educational and Psychological Measurement, 30,607-610. Retrieved October31, 2020. https://journals.sagepub.com/doi/abs/10.1177/001316447003000308

Kishtainy N., Georage A., Farndon J, Kennedy F. Meadway J., Christopher W., and Weeks M. (2012). *The economics book.* Dorling Kindersley Limited, London.

Lcek Ajzen. (2008)., Consumer Attitudes and behavior, Jan 2008., https://www.researchgate.net/publication/264000611

Nguyen Tam Thi & Watanabe Tsunemi. (2019) *Win-win outcomes in waste separation behavior in the rural area: A case study in Vietnam.* Journal of Cleaner Production Vol230 pg 488-498. https://doi.org/10.1016/j.jclepro.2019.05.120

Office of the Permanent Secretary, Ministry of Tourism and Sports. (2560). Complete report on the preparation of national tourism accounts: Project to develop the system and prepare national tourism accounts in year 2560., Pages 7-50.

Parliamentary Budget Bureau. (2560) Parliamentary Budget Bureau Analysis Report Volume No.1 4 / 2560 issued in: Solid Waste Management. https://www.parliament.go.th/ewtadmin/ewt/parbudget/ewt_dl_link.php?nid=465

Phirayut Wannaphut. (2553). *Responding to local environmental issues, waste and wastewater management: guidelines of Thai administrative local organizations*. The College of Local Government Development., King Prajadhipok's Institute

Royal Gazette. (2560). Waste Management Act 2560, Volume 134, Special Issue 267, November 2560.

Seung-Joon Yoon (2020) South Korea's Experience with Smart Infrastructure Services: Integrated Solid Waste Management., *Inter-American Development Bank.* http://dx.doi.org/10.18235/0002672

Scott J. Callanand Janet M. Thomas. (2013). *Environmental Economics & Management Theory, Policy and Applications* 6th Edition, United States of American

Simon Board. (2009). *Consumer Preferences and the Concept of Utility*. https://ibs.colorado.edu/barham/courses/econ3070/ch03_2015.pdf

The Department of Provincial Administration. (2546). Subdistrict Administrative Organization Division. Manual for tax and fee collection of Subdistrict Administrative Organization.

The Pollution Control Department. (2562) Three-year operational plan in 2563-2565., Waste and Hazardous Substance Management Division.

The Strategy and Information office for Phetchaburi Provincial Development Office (2557) The Waste and Hazardous Waste Management Division: Environmental Regional Offices1-16 and 76

Provincial Natural Resources office (2563). Community waste disposal situation report in Thailand 2563

The Oxford Dictionary & English Usage Guide. (1996). Oxford University Press. New York.

Tsuruyo Funatsu (2019) *Toward Regional Cooperation of Local Governments in ASEAN; Municipal Solid Waste Management in Thai Local Governments: The State of the problem and prospects for regional waste management. (Charpter:4)* https://www.ide.go.jp/English/Publish/Reports/Ec/201903.html

Simon Board. (2009). *Consumer Preferences and the Concept of Utility*. https://ibs.colorado.edu/barham/courses/econ3070/ch03_2015.pdf

Ukkonen & Sahimaa, (2021). Weight-based pay-as-you-throw pricing model: Encouraging sorting in household through waste fees., https://doi.org/10.1016/j.wasman.2021.09.011 https://www.sciencedirect.com/science/article/pii/S0956053X21005006

Ward Edwards. (1992). *Utility Theories: Measurements and Applications.* https://www.journals.uchicago.edu/doi/10.1086/289817

Watchira Sitthibort (2553)., *A study on public participation in waste separation in the health service network area of Tha Mai District, Chanthaburi Province.* Burapha University

Wikipedia. (2020). *Solid waste policy of United States.* https://en.wikipedia.org/wiki/Solid

Worrell. W, A., Vesilind P. A and Ludwig C. (2017). *Solid Waste Engineering A Global Perspective, United state of America*.

Yew-Kwang Ng. (2003). From Preserence to happiness: Towards a more completes welfare economics. www.spinglink.com , Volume 2, p307-350 https://link.springer.com/article/10.1007/s003550200184

APPENDIX

Table 1 – Waste Sorting Behavior

	f	%	$\overline{M}$	S.D.
Gender				
Men	159	39.7		
Women	241	60.3		
Age (year(			40.76	13.99
Career				
Employee	93	23.3		
Governor	48	12.0		
Agriculturist	41	10.3		
Office Workers	31	7.8		
Seller	55	13.8		
Students	56	14.0		
Housekeeping	22	5.5		
State Enterprises staff	11	2.8		
Miscellaneous	43	10.8		
Year of Education				
Lower Primamarry school	1	0.3		
Primamarry school	50	12.5		
Secondary School	80	20.0		
High School/ Vocational Certificate	73	18.3		
HighVocational Certificate	46	11.5		
Bachelor's degree	135	33.8		
Master’s Degree or higher	15	3.8		
Marital Status				
Single	140	35.0		
Married	227	56.8		
Widowed	28	7.0		
Divorced	5	1.3		
Family Members) individual(			3.71	1.51
Main Income per month (Baht(				
Less than 10,000	168	42.0		
10 ,000-20,000	133	33.3		
20 ,001-30,000	56	14.0		
30 ,001-40,000	29	7.2		
40 ,001-50,000	4	1.0		
More than50 ,000	10	2.5		
Supplimentary Income per month)Baht(				
Less than10 ,000	379	94.5		
10,000-20,000	15	3.8		
20,001-30,000	5	1.3		
30,001-40,000	1	0.3		
Debt per month)Baht(			3,509.08	7,793.28
Residential owning				
Owned Residential	339	84.8		
Rented Residential,Goverments Living place	61	15.2		

Table 2 – Waste soring Behavior of Respondents

Behavioral data characteristics	*f*	%
Behavioral		
Doing waste sorting	324	81.0
Not doing waste sorting	76	19.0
Frequancy of doing waste sorting		
Waste sorting in daily	166	41.5
Waste sorting 2-3 times per day	24	6.0
Waste sorting in weekly	82	20.5
Waste sorting in monthly	13	3.3
Miscellaneous	112	27.1
Time of doing waste sorting		
Morning time6 .00-8. 00	40	10.0
At Noon time12.00-14. 00	26	6.5
At Evening time16.00-18.00	166	41.5
Doing in convenient time	100	25.0
Not Doing waste sorting	68	17.0
Selling waste as separation per time) Baht(		
Less than 100 Baht per time	137	34.3
101 -1, 000Baht per time	111	27.8
1 ,001-2, 000Baht per time	2	0.5
Reasons of doing waste sorting		
Save the earth	157	21.5
Making compost	43	5.9
Waste sorting for Increasing income	206	28.3
Waste sorting for avoid dismantling from Animal	71	9.7
Waste sorting for house cleanness	169	23.2
Waste sorting for bring to recycle in other equripments	34	4.7
Waste sorting for donation or send to foundation	23	3.2
Announced from local broadcast promoted waste sorting campaign	7	1.0
Leader of community required for waste sorting	10	1.4
Waste sorting for community project e.g. make merit from garbage	9	1.2
Maintain Authorited Town Type: Waste management in Phetchaburi		
Small town size authority (“*Aor Bor Tor”)*	199	49.8
Sub-District Munucipal	108	27.0
Mueang District Municipal	93	23.2

Remark: Multiple Choice in case of waste sorting reasons.

Table 3 – Waste type and waste sorting quantities of respondents

	f	%	$\overline{M}$	S.D.
Surgical Mask	115	9.3	0.1295	0.1707
Bio-Waste	152	12.2	0.0867	0.1106
Papers	97	7.9	0.1106	0.1690
Glass , Glass Bottle	172	13.8	0.9552	3.8744
Cans	93	7.3	0.0597	0.1129
Steel, Metal	15	1.4	0.1737	0.2516
UHT Boxes	42	3.1	0.1317	0.2262
Leaf	39	3.2	0.0787	0.1680
Coca-cola head bottle	16	1.3	0.2729	0.2608
PU FORM food boxes	31	2.4	0.1319	0.2494
Plastic Bottles	297	23.7	0.0217	0.0656
Electrical waste	2	0.6	0.7500	0.3536
Baby Sanitary, Aging Sanitary	10	1.0	0.2800	0.2616
Plastic Bag	113	8.9	0.1194	0.1556
Miscellaneous e.g. drinking paper cup,	49	3.7	0.1094	0.1602
Total	1 ,238	100.0		

Remark: Respondants choosed in multiple choice, and quantily has been normarization data

Table 4 – Result of logistic regression analysis, the determination with existing waste sorting policy

	Coef.	SEE	Marginal Effect
Year of education	0.0617	0.0844	0 . 0042→ 0.42%
Ages	0.0015	0.0188	0.0001 → 0.01%
Monthly Income	6.7E-06	3.9E-05	4.5E-07 → 0.00%
Debt of Household	-2.0E-05	4.2E-04	-1.3E-06→ 0.00%
Family Menbers Quantity	-0.2588**	0.1308	-0.0175 → -1.75%
Household Location,Stated:	-0.9506**	0.4074	-0.0642 → -6.42%
Rural	19.4269***	3.1840	0.3115 → 31.15%
Household Quantities			
Policies (existing)			
Waste Bank Policy	0.1683	0.4771	0.0114→1.14%
Promoting: Waste Sorting	2.3219***	0.6502	0 .1568→15.68%
Bio-Waste Compost	0.7090	0.4918	0.0479→ 4.79%
Recycle plastic by making bag	-0.5955	0.5075	-0.0402→ -4.02%
constant	-2.2664*		
Observations	400		
Likelihood Ratio: Chi-squared	218.86**		
Pseudo R-squared	56.27%		
Model Accuracy	93.75%		

Remark: ***P<0.01, **P<0.05, *P<0.10

Table 5 – Results of logistic regression estimators implication test of motivation incentive policy

	Coef.	**SEE**	**Coef.**	**SEE**	**Coef.**	**SEE**	**Coef.**	**SEE**	**Marginal effect**
Household Quantities	21.9775***	3.3023							0.→892989.29%
Household Quantities			21.9280***	3.3173					0.8224→82.24%
Household Quantities					22.0113***	3.3242			0.8144→81.44%
Household Quantities							22.1975***	3.3349	0.9042→90.42%
Motivative incentive waste separation									
Discount Fee, sorting in bio-waste	-0.0079	0.4318							-6.8E-04→-0.07%
Pay as actural, sorting in waste			-0.9817**	0.4183					-0.0816→ -8.16%
Obtain Alternative Benefit, sorting in waste					0.9410***	0.3647			0.0776 → 7.76%
Refund revenue tax, sorting in waste							-0.3506	0.4013	-0.0301 →-3.01%
Constant									
Observations									
Likelihood Ratio: Chi-squared									
Pseudo R-squared									
Model Accuracy									

Remark: ***P<0.01, **P<0.05, *P<0.1

THE CONSTRUCTION OF A MODEL AND PROMOTION STRATEGIES FOR OPEN UNIVERSITY TEACHERS' DIGITAL COMPETENCE FROM AN INTERNATIONAL PERSPECTIVE

Hou Haibing[A], Long Jingyi[B]

ABSTRACT

Under the background of education digitalization, the competency requirements for Open University teachers are continuously increasing. To adapt to the digital development trend of open education, teachers need to enhance their digital literacy, innovate educational skills, and balance technology with ethical considerations to achieve digital competence. Based on practice-oriented approaches, development principles, and ethical norms, a comprehensive review of the development status of digital competence in both domestic and international Open Universities was conducted. Through qualitative research, a digital competence model framework for Open University teachers was constructed. This model includes six primary dimensions: intercultural communication competence, the ability to develop and integrate digital teaching resources, online teaching design and implementation, innovation in information technology, international exchange and cooperation, and digital security and ethics. These six primary dimensions are further broken down into 12 secondary dimensions. Additionally, strategies for promoting Open University teachers' digital competence from an international perspective were proposed. These strategies include enhancing intercultural communication skills, promoting the construction of digital resources, establishing a digital training system, improving core competencies in information technology, and forming a digital security mechanism.

Keywords: *Education Digitalization, Digital Literacy, Digital Competence, Intercultural Communication Competence, International Perspective*

INTRODUCTION

Driven by the wave of globalization, educational internationalization has become a significant trend in the development of higher education. Open universities, with their characteristics of openness, flexibility, and internationalization, have attracted a large number of learners. However, the rapid development of open universities has also raised higher requirements for teachers' digital competence. In the context of digital technology increasingly dominating educational transformation, the crucial role of teachers in the digitalization of education is becoming more prominent. Countries and international organizations are actively promoting the integration of digital technologies into education, and enhancing teachers' digital

[A] *School of Applied English Department, Guangdong Open University, Guangzhou, Guangdong, China. Email: 258266443@qq.com. Orcid: https://orcid.org/0000-0002-0627-8439*

[B] *School of Cultural Communication and Design, Guangdong Open University, Guangzhou, Guangdong, China. Email: jylong@gdrtvu.edu.cn. Orcid: https://orcid.org/0000-0002-0627-8439*

skills and literacy has become a necessary condition for achieving the United Nations' Sustainable Development Goal 4—Quality Education (Chaklaw, 2023).

Particularly in 2023, global attention to large models and generative artificial intelligence increased significantly, driving the development of digital education. The 2024 Government Work Report also clearly emphasized the need to vigorously develop digital education, build a highly qualified and professional teaching workforce (Li, 2024) . Notice from the Ministry of Education in China and Eight Other Departments on the Issuance of the "Action Plan for Improving the Quality and Excellence of Vocational Education (2020-2023) promotes "Internet+" and "Smart+" education models, and actively "guide vocational schools to carry out comprehensive digital training to enhance the digital capabilities of teachers and administrative staff". For open universities, digital transformation has become an urgent task, as the digital competence of teachers is directly linked to whether open university education can meet the demands of the intelligent era. However, research indicates that many open university teachers have not yet developed a digital competence framework that is suited to intelligent education, facing numerous challenges in improving their digital skills.

LITERATURE REVIEW

This study conducted a literature review from two perspectives: digital competence and digital competence development for teachers in Open Universities.

Digital Competence

Digital competence, as an independent concept, emerged in the late 20th to early 21st century. The European Union first identified digital competence as one of the eight key competences in its 2006 Framework of Key Competences for Lifelong Learning, emphasizing the ability to confidently, critically, and creatively use information and communication technology (ICT) in work, study, social interaction, and entertainment in the 21st century (Ferrari, 2013). Domestically, scholars such as Zheng Xudong argue that digital competence is a collection of skills that enables teachers to effectively use digital technology in teaching activities to achieve high-quality educational outcomes (Zheng, 2019).

In the open university teaching environment, digital competence is particularly crucial due to the diversity of learners and the personalized learning needs. Open university education often transcends the traditional constraints of time and space, with learners coming from different regions and cultural backgrounds, each with varying learning habits and preferences. This requires teachers to flexibly use information technology and digital teaching resources to design teaching plans that meet learners' needs, providing personalized learning support and services (Yan & Liu, 2022).

Digital competence for open university teachers refers to the comprehensive ability to use digital technologies to carry out teaching and innovative communication activities in the context of the digital and artificial intelligence era. This competence not only includes the use of multimedia resources and online interactive tools to enhance the engagement and liveliness of teaching but also involves using data analysis and learning feedback to accurately track students’ learning progress and needs, thereby optimizing teaching strategies and offering personalized support. Furthermore, the digital competence of open university teachers should

encompass critical innovation of information content and a strong sense of ethical responsibility. The digital competence of open university teachers is vital for improving teaching quality, learning outcomes, and fostering innovative thinking. It is a core quality for achieving the goal of high-quality education in a digital teaching environment.

Digital Competence Development For Teachers In Various Open Universities

According to Zhang Yi et al. (2023), the Open University of the United Kingdom is a pioneer not only in Europe but also globally in integrating artificial intelligence into open education. The university has developed a learning analytics system that utilizes machine learning algorithms to identify students at risk of failing exams. This information is then communicated to tutors and learning support teams, allowing them to provide targeted support and interventions. Furthermore, the university has established a student data usage policy to ensure all operations are conducted ethically, respecting student privacy, and safeguarding the security of students and their data.

Indonesia's Universitas Terbuka has built a digital learning ecosystem to enhance teachers' digital competence. By offering digital textbooks, virtual reading rooms, TV courses, remote tutoring applications, in-person tutoring, and an online exam system, the university provides students with a high-quality online, remote, and flexible learning experience.

Anadolu University in Turkey has implemented a digital strategy to improve teachers' digital literacy. The university has developed a learning management system that provides a variety of digital self-learning resources, covering both degree and non-degree programs. Additionally, it conducts research projects to enhance the training quality of distance education practitioners and researchers.

Open University Malaysia emphasizes teacher training in deep learning pedagogy, developing internal learning systems such as myINSPIRE and the myOUM app to optimize learner management systems. It collaborates with industries to develop digital courses, introduces xMOOCs and Open Educational Resources (OERs), and incorporates machine learning to improve system intelligence and user experience. The university also adopts digital innovation to enhance the interactivity of learning materials, increase self-assessment tools, and improve video lectures based on course content.

Costa Rica's National University for Distance Education has made significant efforts to enhance teachers' digital competence and promote digitalization, aiming to create an equitable, democratic, and harmonious learning environment. Measures include providing diverse digital teaching resources, real-time online tutoring, and the use of virtual learning platforms. The university promotes the development of the educational environment by integrating technology, civic awareness, ethics, and human values, viewing education as a public value that fosters social mobility and creates more development opportunities for all.

Enhancing teachers' digital competence is essential to improving the quality of the open education system. The National Open University drives educational reforms through digitalization, leveraging digital technologies to enhance the teaching process, comprehensive assessment, learning resources, and the digital level of talent development. This promotes the development of teachers' digital competence and supports the holistic growth of students. Sichuan Open University has optimized and integrated its online teaching system, constructed

a comprehensive learning support system, and advanced the development and sharing of digital learning resources. It has also utilized credit bank functions to build a lifelong learning platform. Guangdong Open University has established an integrated platform for degree and non-degree education, consolidating open education, adult education, senior education, and social training. This has achieved the deep integration of information technology and education.

DATA AND METHODOLOGY

The present study utilized the descriptive qualitative research design. It used methods such as induction and deduction, analysis and synthesis, abstraction, and generalization to clearly reveal the inner laws of things. This study analyzed and compared previous research, and based on that, through semi-structured interviews, it synthesized and constructed a model of digital competence for open university teachers from an international perspective. By conducting comparative analysis, the study summarized and identified strategies for promoting the digital competence of open university teachers.

RESULTS AND DISCUSSION

Based on the investigation, analysis of previous studies, and semi-structured interviews, this study constructs a digital competence model framework for open university teachers from the perspective of the characteristics of open university education and teaching. The framework is built around six primary dimensions, 12 secondary dimensions, and 36 tertiary dimensions, including intercultural communication competence, digital teaching resource development and integration, online teaching design and implementation, information technology innovation, international exchange and cooperation, and digital security and ethics. The study also proposes strategies for promoting the digital competence of open university teachers from an international perspective: enhancing intercultural communication skills, advancing the development of digital resources, establishing a digital training system, improving core competencies in information technology, and forming a digital security mechanism.

Construction of A Digital Competence Model for Open University Teachers

By analyzing the EU Framework for the Digital Competence of Educators, the ICT Competency Framework for Teachers, the ISTE Standards for Educators, and the education industry standards for Teachers' Digital Literacy, it was found that the common keywords include teachers, students, teaching, technology, profession, assessment, resources, and security(Liu, 2024).

This paper constructs a digital competence model framework for open university teachers, based on the characteristics of open university education and teaching, from six primary dimensions: intercultural communication competence, digital teaching resource development and integration, online teaching design and implementation, innovation in information technology, international exchange and cooperation, and digital security and ethics. These six primary dimensions are further divided into 12 secondary dimensions and 36 tertiary dimensions.

Table 1 – A Digital Competence Model for Open University Teachers

Primary	Secondary	Tertiary
Intercultural Communication Competence	Intercultural Communication Skills	Understanding and Respecting Diverse Cultural Backgrounds
		Effectively Communicating with Students from Different Cultures
		Using Tools to Promote Intercultural Communication and Cooperation
	Intercultural Communication Skills	Incorporating Cultural Diversity into Teaching Design
		Creating an Inclusive Learning Environment
		Managing Intercultural Conflicts
Development and Integration of Digital Teaching Resources	Intercultural Communication Skills	Designing Teaching Resources Using Digital Technology
		Developing Teaching Materials that Meet the Needs of Different Learners
		Creating Interactive Digital Content
	Cultural Adaptation and Inclusion	Using Multimedia Technology to Enhance Teaching Effectiveness
		Integrating Various Digital Resources into Teaching Activities
		Evaluating and Selecting Appropriate Multimedia Tools
Online Teaching Design and Implementation	Cultural Adaptation and Inclusion	Designing Course Structure Using Online Platforms
		Developing Online Content Using Teaching Strategies
		Designing Online Activities Based on Learners' Needs
	Cultural Adaptation and Inclusion	Implementing Synchronous and Asynchronous Online Teaching
		Using Data Analysis to Improve Teaching
		Providing Personalized Learning Support and Feedback
Information Technology Innovation	Design and Development of Digital Teaching Resources	Using the Latest Educational Technology to Innovate Teaching
		Using Emerging Technologies (e.g., AI, VR) for Teaching
		Developing Technological Solutions for Future Education
	Integration and Application of Multimedia Resources	Integrating Various Digital Tools to Achieve Teaching Goals
		Continuously Optimizing the Use of Online Teaching Tools
		Exploring Innovative Models like Blended Learning
International Exchange and Cooperation	Online Course Design	Participating in International Projects and Educational Research
		Collaborating with Foreign Educational Institutions in Joint Teaching
		Sharing International Educational Resources
	Online Course Implementation and Feedback	Developing Course Content with an International Perspective
		Incorporating Global Knowledge and Cases
		Using Globalized Teaching Tools and Resources

Primary	Secondary	Tertiary
Digital Security and Ethics	Innovation in the Application of Digital Technology	Safeguarding Student Privacy and Data Security
		Complying with International and National Data Protection Regulations
		Managing Data Access in Digital Teaching
	Optimization of Digital Tools and Innovative Teaching Models	Identifying and Addressing Ethical Challenges in Digital Teaching
		Balancing Technology Use with Ethical Considerations
		Ensuring Fairness and Justice in Digital Teaching

First, Intercultural Communication Competence

The "Intercultural Communication Competence" dimension is the foundation of the digital competence framework for open university teachers from an international perspective. Open universities often cater to learners from diverse cultural backgrounds, and teachers need to possess intercultural communication skills to effectively impart knowledge in a multicultural learning environment. Digital teaching transcends geographical boundaries, and teachers must understand and respect cultural differences, interact with students from around the world through digital tools, and enhance the inclusiveness and global perspective of their teaching. This involves not only linguistic communication but also understanding and embracing different cultural customs and values (Cao,2021).

Second, Digital Teaching Resource Development and Integration Competence

The "Digital Teaching Resource Development and Integration Competence" dimension is a key aspect of the digital competence framework for open university teachers from an international perspective. This competence requires teachers to design, develop, and integrate a variety of digital teaching resources, using diverse teaching activities to meet the needs of different learners (Haşlaman et al., 2024). Teachers should be proficient in using multimedia resources (such as videos, audio, images) and various teaching tools, optimizing existing resources and creatively designing engaging content to enhance the effectiveness and interactivity of teaching.

Third, Online Teaching Design and Implementation Competence

The "Online Teaching Design and Implementation Competence" dimension is a crucial element of the digital competence framework for open university teachers. This competence demands that teachers design course structures, develop teaching strategies, and effectively implement courses in an online teaching environment. Teachers should be able to apply appropriate teaching methods and technical tools to guide student learning, ensure the smooth implementation of online courses, and adjust teaching plans based on effective feedback mechanisms to improve learning outcomes (Geronimo et al., 2024).

Fourth, Information Technology Innovation Competence

The "Information Technology Innovation Competence" dimension is the core of the digital competence framework for open university teachers from an international perspective. This competence requires teachers to apply the latest information technologies in innovative ways to enhance teaching effectiveness. Teachers need to stay updated with technological advancements, such as artificial intelligence and virtual reality, and use these tools to develop new teaching models and methods (Judijanto et al., 2024), meeting the diverse needs of learners and continually exploring innovations in teaching processes and resource allocation.

Fifth, International Exchange and Cooperation

The "International Exchange and Cooperation" dimension is a pillar of the digital competence framework for open university teachers from an international perspective. In this global context, teachers must possess the ability to collaborate with international peers, participate in global education projects, and develop internationally-oriented curricula (Hlavatá & Simon, 2024). In the era of digitalization and artificial intelligence, this dimension enables open university teachers to expand their global educational perspective, share resources and experiences through international cooperation, and enhance the internationalization of their teaching content, ensuring they can meet the demands of globalized education. Thus, it is one of the key dimensions supporting teachers' adaptation to the diversity and globalization of the teaching environment.

Sixth, Digital Security and Ethics

The "Digital Security and Ethics" dimension is the safeguard of the digital competence framework for open university teachers from an international perspective. This competence requires teachers to ensure the privacy and security of both student and teacher data in a digital teaching environment while adhering to ethical standards. Teachers must be capable of using data responsibly, complying with relevant laws and regulations, and balancing the relationship between technology and ethics to ensure fairness and justice in the use of technology.

These six dimensions collectively form a comprehensive and interconnected digital competence framework for open university teachers. This framework not only helps teachers enhance their digital competence but also promotes their professional development and improves the overall learning experience of students.

Current Status of Digital Competence of Open University Teachers

Based on the six dimensions discussed earlier—intercultural communication competence, digital teaching resource development and integration, online teaching design and implementation, information technology innovation, international exchange and cooperation, and digital security and ethics—it can be observed that there are varying degrees of gaps and challenges in the development of digital competence among open university teachers.

I. Weak Intercultural Communication Competence

Currently, open university teachers exhibit relatively weak intercultural communication competence. Open universities serve learners from diverse cultural backgrounds worldwide, and teachers are expected to have strong intercultural communication skills to understand and respect cultural differences. However, some teachers lack practical opportunities and professional training in intercultural communication, which hinders their ability to effectively address cultural differences and impacts the establishment of teacher-student relationships and the enhancement of teaching outcomes (He et al., 2024).

II. Challenges in Developing and Integrating Digital Teaching Resources

In the digital age, open university teachers face many challenges in the development and integration of digital teaching resources (Rafiq et al., 2024). Although many teachers possess basic technological skills, there are still deficiencies in applying these skills to the development and effective integration of teaching resources. Skills related to integrating teaching resources on online platforms, developing diverse and engaging multimedia teaching content, have yet to be fully developed.

III. Weak Online Teaching Design and Implementation Competence

According to Wu (2024), online teaching design and implementation competence is critical to ensuring teaching quality, yet many open university teachers lack proficiency in this area. Online teaching requires teachers to be familiar with virtual teaching platforms, design interactive teaching activities, and continuously optimize teaching effectiveness through data feedback. However, some teachers are not skilled in the design and management of online teaching, particularly in stimulating student engagement and promoting interaction, which significantly impacts students' learning experiences and outcomes.

IV. Insufficient Information Technology Innovation Competence

With the rapid development of technology, information technology innovation has become a core driving force in education. However, some open university teachers show insufficient performance in innovatively applying information technology. They are often conservative in applying emerging technologies (such as artificial intelligence, big data, and virtual reality) and tend to rely more on traditional teaching models. Teachers lack a keen sense of awareness and practical ability to apply the latest technologies, which limits their ability to improve teaching quality and student engagement.

V. Lack of International Exchange and Cooperation Competence

An international perspective and competence in international exchange and cooperation are essential qualities for open university teachers, but many teachers are still lacking in this regard. Although globalization continues to grow and opportunities for teachers to engage in international academic exchanges and collaborative research are increasing, some teachers lack experience in participating in international projects and have low proficiency in English, making it difficult for them to effectively utilize international resources and share teaching outcomes (Alzaanin, 2024). This makes it harder for them to integrate into the wave of global educational reforms.

VI. Weak Awareness of Digital Security and Ethics

In a digital teaching environment, teachers' awareness of digital security and ethics is crucial. As technology becomes more widespread, issues of data privacy and information security are becoming increasingly prominent. However, some open university teachers do not place enough emphasis on digital security and ethical concerns. Their understanding of student data protection, privacy policies, and ethical issues in digital teaching is insufficient, which may lead to potential teaching risks. This not only affects the quality of teaching but also poses potential legal and ethical challenges.

Strategies for Advancing Digital Competence of Open University Teachers in an International Context

I. Development-Oriented Approach to Enhance Intercultural Communication Competence

Teachers should participate in international education exchange programs, cultural training, and other activities to enhance their understanding and tolerance of global cultural diversity. This not only broadens teachers' international perspectives but also helps them become more adaptable when interacting with students from different cultural backgrounds, allowing them to better understand students' learning needs and adjust their teaching strategies accordingly. Proficiency in foreign languages helps teachers better understand students' thought processes and cultural backgrounds, facilitating smoother teaching interactions.

II. Technology-Supported Approach to Promote Digital Resource Development

According to Wang and Mei (2024), to address the rapid growth of digital education, open universities need to promote the optimization and application of digital teaching tools, improving the flexibility and efficiency of teaching management through advanced technological platforms. By using digital tools, teachers can master systematic digital teaching methods and ensure they effectively utilize and integrate various technological resources during their teaching processes. The effectiveness of digital technology applications should be enhanced. For example, artificial intelligence, data analytics, and cloud technology can be used to promote intelligent teaching management, allowing real-time tracking of students' learning behaviors and teaching activities to optimize teaching outcomes. Open universities should continuously offer relevant technical support and training opportunities, such as regular seminars, workshops, and online courses, to improve teachers' ability to use digital tools and their teaching design skills. By optimizing digital teaching tools, teachers can create more interactive, collaborative, and innovative teaching environments, offering students a diverse and personalized learning experience.

III. Learning-Centered Approach to Build a Digital Training System

The improvement of teachers' digital competence relies on effective practice-oriented training. The enhancement of teaching competence should revolve around practice, clarifying the core requirements and components of teachers' digital competence in open universities, and building a comprehensive practice-based training system. In line with Nugroho, A. et al., through contextual teaching, case analysis, and project-based practice, teachers' awareness of digital technology application can be strengthened. At the same time, a sound evaluation and incentive mechanism should be established, focusing on cultivating teachers' digital leadership and continuously optimizing the outcomes of practice-based training. Clearly defining the components of teachers' digital competence, including basic technological applications, teaching resource integration, innovative teaching design, and digital security awareness, provides clear directions and goals for competence improvement.

IV. Innovation-Oriented Approach to Enhance Information Technology Competitiveness

In the rapid development of digital education, open university teachers should focus on innovation as the core to continuously enhance their competence in applying information technology. According to Rong (2022), by mastering and applying emerging technologies, such as artificial intelligence, big data, and virtual reality, teachers can optimize teaching methods, increase classroom interactivity, and improve students' learning outcomes. Additionally, teachers should actively participate in technical training and practice, exploring the application of new technologies in teaching, increasing the flexibility and innovation of teaching, and ensuring competitiveness in an ever-evolving educational environment.

V. Collaboration-Oriented Approach to Establish a Digital Support System

In agreement with ZIHAN (2023), in advancing the digital transformation of vocational education, the improvement of teachers' digital competence requires multi-party collaboration, guided by national policies, close cooperation between industries and enterprises, and the rational allocation of teaching resources to form a comprehensive digital support system. First, it is necessary to ensure the standardization and regulation of digital teaching. Based on relevant national policies and in accordance with the Standards for Teachers' Digital Literacy, vocational school teachers should be guided to maintain alignment with national educational objectives in course design, teaching implementation, and evaluation. Secondly, emphasis should be placed on the practical application of digital technology innovation. Enterprises are

not only important sources of technological innovation but also core platforms for talent cultivation. By strengthening the integration of industry and education, enterprises can bring the latest industry trends, technical equipment, and practical experience to vocational education, driving the updating and innovation of teaching content and methods. Lastly, attention should be paid to the practicality of digital teaching resources. The development and application of teaching resources must closely align with actual work scenarios to ensure their adaptability and effectiveness. Establishing corresponding standards for information-based teaching competence, covering all aspects of digital teaching, will help enhance the intelligence level of teaching management and promote the comprehensive development of teachers' professional competence.

CONCLUSION

In the context of educational internationalization, with the continuous iteration of digital technologies and the growing diversity and personalization of educational needs, teachers will become not only transmitters of knowledge but also creators of teaching content and innovators of learning methods. This is not only a means of improving their professional competencies but also an adaptation to the open education ecosystem, contributing to the cultivation of skilled talents needed for future societal development. Although the proposed digital competence model framework for open university teachers provides a clear direction for their professional development offering a strategic reference for policymakers and institutional administrators in implementing digital transformation, there is still much room for improvement. More studies are expected to focus on the digital competence for open university teachers and proposing a more systematic and comprehensive digital competence model framework.

REFERENCES

Alqodsi, E. M., Jadalhaq, I. M., El Maknouzi, M. E. H., & Abdulhay, I. E. A. (2024). Navigating the legal landscape: AI adoption in education and teacher responsibilities. In *Cutting-edge innovations in teaching, leadership, technology, and assessment* (pp. 212-230). IGI Global.

Alzaanin, E. I. (2024). Capturing the emotional experiences of English as a foreign language university teachers: A critical perspective. *Language Teaching Research, 28*(3), 931-947.

Cao, Y. (2021). *How to integrate intercultural communication in Chinese language teaching: An interpretive study of the perspectives and experiences of teachers in Confucius Institutes in the United Kingdom* (Doctoral dissertation, Durham University).

Chaklaw, B. (2023). The complexity of teachers' digital skills and teaching abilities in the age of digitalization and artificial intelligence and coping strategies. *International Educational Exchange, (5).*

Ferrari, A. (2013). DIGCOMP: A framework for developing and understanding digital competence in Europe. *JRC Publications Repository*.

Geronimo, C. A., Adriano, R. C., & Celestino, J. R. F. (2024). Learnings, issues, and challenges encountered by students and faculty members in the implementation of small private online courses (SPOCs). *International Journal of Multidisciplinary: Applied Business and Education Research, 5*(2), 696-710.

Haşlaman, T., Atman Uslu, N., & Mumcu, F. (2024). Development and in-depth investigation of pre-service teachers' digital competencies based on DigCompEdu: A case study. *Quality & Quantity, 58*(1), 961-986.

He, S., Wang, Z., Wang, T., Ge, D., & Khampheera, S. (2024). Examining the significance of intercultural communicative competence development in trainees during pre-service training. *Journal of Psycholinguistic Research, 53*(1), 14.

Hlavatá, L., & Simon, A. (2024). Internationalisation without international students? Internationalising the curriculum and student experience during the COVID-19 pandemic in Slovakia. *Innovations in Education and Teaching International*, 1-15.

Judijanto, L., Atsani, M. R., & Chadijah, S. (2024). Trends in the development of artificial intelligence-based technology in education. *International Journal of Teaching and Learning, 2*(6), 1722-1723.

Li, Q. (2024). Government work report 2024 [EB/OL]. (2024-03-12) [2024-04-01]. https://www.gov.cn/yaowen/liebiao/202403/content_6936260.htm.

Liu, Q. G. (2024). The value implications, current development, and enhancement strategies for vocational school teachers' digital competence in the age of intelligence. *Vocational Education Development Research, 2*, 53-61.

Ministry of Education and Eight Other Departments. (2020). Notice from the Ministry of Education and Eight Other Departments on the issuance of the "Action Plan for Improving the Quality and Excellence of Vocational Education (2020-2023)": Document No. 7 [2020] [EB/OL]. (2020-09-16) [2024-04-01]. https://www.gov.cn/zhengce/zhengceku/2020-09/29/content_5548106.htm.

Nugroho, A., Triana, Y., & Zulaiha, D. (2022). Digital teaching awareness and practice: Narratives from Indonesian ESP teachers. *ELT Echo: The Journal of English Language Teaching in Foreign Language Context, 7*(1), 1.

Rafiq, S., Iqbal, S., & Afzal, A. (2024). The impact of digital tools and online learning platforms on higher education learning outcomes. *Al-Mahdi Research Journal (MRJ), 5*(4), 359-369.

Rong, J. (2022). Innovative research on intelligent classroom teaching mode in the “5G” era. *Mobile Information Systems, 2022*(1), 9297314.

Wang, J., & Mei, H. (2024). The construction and promotion strategies of a digital competence model for vocational school teachers in the context of education digitalization. *Education & Vocation, (14)*.

Wu, Y. (2024). Strategies and recommendations to enhance online English teaching quality in higher vocational colleges. *Pacific International Journal, 7*(3), 43-46.

Yan, G. F., & Liu, L. (2022). Research on teachers' digital literacy and its cultivation paths: A comparative analysis based on seven digital literacy frameworks from the European Union. *Comparative Education Review, 44*(3), 10-18.

Zhang, Y. L., Sihan, Hou, S. Y., & Li, W. (2023). Digitalization actions and insights in open education from an international perspective: A summary of the First World Open University Presidents Forum.

Zheng, X. D. (2019). *Construction and application research of a digital competence model for primary and secondary school teachers in China* (Doctoral dissertation, East China Normal University, Shanghai).

Zihan, Z. (2023). *Study on teachers' satisfaction with digital educational resource sharing in Nanchang area universities* (Doctoral dissertation, SIAM University).

EXPLORING MENTAL HEALTH ISSUES, NEEDS, AND THE ROLE OF COUNSELING SERVICES FOR STUDENTS AND STAFF AT OPEN UNIVERSITY MALAYSIA (OUM)

Mohd Azli Jailani[A], Hazrul Hizam Karim[B], Mohd Fakardian Che Rus[C], Azleen Ismail[D]

ABSTRACT

This study investigates mental health challenges and the role of counseling services at Open University Malaysia (OUM), focusing on the distinct needs of students and staff in an open university environment. Using a qualitative phenomenological method, 23 participants, including undergraduate students, master's students, administrative staff, and academic staff, were selected for semi-structured focus group interviews. Thematic Analysis was employed to analyze the data. The study reveals that students' counseling needs fall into three main areas: managing academic demands, career development, and personal challenges. Meanwhile, the counseling needs of academic and administrative staff are centered on academic workload, communication, and administrative demands. Students identified two primary factors affecting their mental health: challenges related to Online Distance Learning (ODL) and personal issues. Academic and administrative staff pointed to four key factors: academic management, student management, academic workload, and the work environment. To improve counseling services, participants suggested three key areas: mental health awareness campaigns, enhanced service accessibility, and dedicated counseling services for staff. These findings emphasize the necessity for specialized mental health support in open universities to effectively meet the specific challenges faced by students and staff, ensuring a more supportive learning and working environment at OUM.

Keywords: *counseling needs, mental health factors, counseling and mental health services, open distance learning, open university*

INTRODUCTION

In recent years, the recognition of mental health as a fundamental aspect of academic and professional success has gained prominence. Williams et al. (2017) revealed that stress levels among academic staff have increased significantly over the last 20 years. Similar trends can be seen in university students as Kumaran et al. (2022) explained that the prevalence of

[A] *PhD, Faculty of Social Sciences and Humanities, Open University Malaysia, Selangor, Malaysia. Email: mohdazli_jailani@oum.edu.my Orcid: https://orcid.org/0009-0008-7675-2176*

[B] *PhD, Faculty of Social Sciences and Humanities, Open University Malaysia, Selangor, Malaysia. Email: hazrulhizam@oum.edu.my Orcid: https://orcid.org/0009-0006-8530-6827*

[C] *MA, Faculty of Social Sciences and Humanities, Open University Malaysia, Selangor, Malaysia. Email: fakardian@oum.edu.my Orcid: https://orcid.org/0009-0006-2303-2365*

[D] *MA, Center for Learner Affairs, Open University Malaysia, Selangor, Malaysia. Email: azleen_ismail@oum.edu.my Orcid: https://orcid.org/0009-0005-7989-3730*

mental health diseases among Malaysian students has risen dramatically over the last decade. Students and staff alike encounter a myriad of stressors, ranging from academic pressures to workplace demands, which can significantly impact their mental well-being.

In the context of Open and Distance Learning (ODL) institutions, these challenges are further exacerbated due to the unique nature of remote education. For instance, ODL students often face difficulties in managing time effectively (Aznira Zainal, 2023). Additionally, students who are studying in ODL mode frequently experience feelings of isolation, which contributes to increased levels of anxiety and depression (Kirin et al., 2022). The lack of face-to-face interaction with peers and instructors can hinder the sense of community and belonging, leading to feelings of disconnection and loneliness. Furthermore, balancing household responsibilities, especially among adult learners, creates further stress. In a case study of working mothers enrolled in ODL programs, it was reported that most are motivated, but they also face many challenges with juggling many things (Fensie et al., 2023).

Staff at ODL institutions are not immune to these pressures either. The shift to online teaching has posed significant technological challenges, which are especially burdensome for staff who may not be well-versed in digital tools. Academic staff in ODL institutions often report increased workload and insufficient institutional support. These factors contribute to heightened stress and anxiety, ultimately affecting their productivity and job satisfaction. For instance, the nature of ODL institutions that expect their academic staff to be available around the clock due to the flexibility of online platforms can lead to severe stress and eventual burnout among the staff (Inegbedion, 2017).

These scenarios highlight the urgent need for mental health support in ODL institutions. Implementing robust mental health programs, such as counseling services and stress management workshops, is essential to fostering a healthier academic environment for both students and staff.

Problem Statement

Currently, the discourse on mental health has gained significant attention, emphasizing its critical role in academic success, personal well-being, and the overall campus environment. While studies by Kelloway et al. (2023), Kamaruzaman et al. (2021), and McMaster et al. (2021) have explored various aspects of this issue, the specific mental health challenges faced by the diverse student and staff population at Open University Malaysia (OUM) remain relatively underexamined. As OUM works to enhance its support systems, there is an urgent need for a comprehensive investigation into the unique mental health concerns, individual needs, and the effectiveness of current counseling services. This research seeks to fill the gap in understanding the complexities of mental health within the OUM community, enabling the development of targeted interventions and policies that foster a more supportive and nurturing environment for the holistic well-being of all its members.

Research Objectives

a) To explore the counseling needs of students and staff at OUM.
b) To analyze the contributing factors to mental health issues among students and staff at OUM.
c) To propose policy enhancements for counseling and mental health services at OUM.

Research Questions

a) What are the specific counseling needs of students and staff at OUM?
b) What are the contributing factors to mental health issues among students and staff at OUM?
c) What policy enhancements can be proposed to improve counseling and mental health services at OUM?

LITERATURE REVIEW

This literature review explores the specific counseling needs of students and staff in ODL institutions, examines the contributing factors to their mental health challenges, and offers suggestions for policy enhancements to improve mental health services.

Specific Counseling Needs of Students and Staff in ODL Institutions

Counseling Needs of Students

Students in ODL institutions face academic, social, and emotional pressures that differ from those in traditional universities. Research shows that ODL students often juggle work, family, and academic responsibilities, leading to high-stress levels and burnout (Deng et al., 2022). Their counseling needs encompass time management, coping with stress, and managing academic expectations. Since many ODL students are adult learners, issues such as career counselling, financial management, and family conflicts are also prominent (John, 2021). Additionally, ODL students may experience isolation, which heightens feelings of loneliness and anxiety (Ng & Lee, 2022). The lack of in-person interaction with peers and faculty members further exacerbates these challenges. Therefore, counseling services in ODL institutions must provide mental health support that addresses these specific issues, including fostering social connections and building resilience.

Counseling Needs of Staff

University staff, including academic and non-academic personnel, face different pressures. They must balance the expectations of facilitating a quality education while managing administrative tasks, and often face job insecurity (Awang et al., 2021). The mental health challenges faced by staff members often include stress, anxiety, burnout, and work-life imbalance (Chakraborty, 2024). Moreover, faculty members who are tasked with supporting students in an ODL environment often experience role overload, leading to feelings of helplessness and emotional exhaustion. This suggests that the counseling services for staff must focus on stress management, professional development, and mental health literacy.

Contributing Factors to Mental Health Issues Among Students and Staff in ODL Institutions

Academic and Workload Pressures

One of the most significant contributing factors to mental health issues among ODL students is the intense workload, particularly for working adults. The pressures of managing

academic requirements, employment, and family responsibilities simultaneously often lead to stress, anxiety, and burnout. The flexibility of ODL, while beneficial in some respects, can exacerbate these pressures by requiring students to practice extreme self-discipline and time management skills (Bellare et al., 2021).

For staff, the growing demands of digital education, such as adapting to new technologies and providing continuous support to students in a virtual environment, increase job-related stress. Furthermore, academic staff often struggle with maintaining work-life balance due to the high expectations of research, teaching, and administrative duties (Bezuidenhout, 2015).

Social Isolation and Lack of Peer Support

ODL students, especially those who study remotely, often report feelings of loneliness and isolation due to limited face-to-face interaction with their peers and instructors (Liu & Lin, 2024). This social isolation is compounded by the nature of online learning, which tends to reduce spontaneous social interactions, potentially increasing the risk of depression and anxiety. Similarly, university staff who work in decentralized or online contexts may experience professional isolation, which negatively impacts their mental well-being (Tobia et al., 2024).

Financial and Personal Challenges

Many ODL students are working adults, and financial difficulties are often cited as a key source of stress. Balancing the costs of education with family and career responsibilities places a considerable financial burden on students, further contributing to anxiety and emotional distress (Archuleta et al., 2013). Additionally, personal challenges such as marital stress, parenting, and caregiving responsibilities add to the mental health challenges of both students and staff.

Policy Enhancements to Improve Counseling and Mental Health Services in ODL Institutions

Expanding Access to Mental Health Resources

Given the diverse and widespread geographical locations of ODL students, expanding access to online mental health services is essential. This can include virtual counseling sessions, online mental health workshops, and the development of a digital platform for peer support groups (Mohamad, 2023). The provision of mental health apps, online self-help resources, and access to teletherapy could be instrumental in improving students' and staff's well-being.

Strengthening Peer Support Systems

The integration of peer support groups within universities' online platforms can be a crucial step toward reducing feelings of isolation. Research suggests that peer mentoring programs and student support groups can significantly alleviate loneliness and improve academic and personal outcomes (Collings et al., 2014; Pointon-Haas, et al., 2023). Policies that encourage peer interaction and provide training for peer counsellors can create a more supportive learning environment.

Promoting Work-Life Balance for Staff

To address the mental health needs of university staff, policies that promote work-life balance are critical. This could include more flexible working hours, increased access to professional counseling services, and mental health training for supervisors and managers. Additionally, providing clear expectations and reducing excessive workloads can help alleviate burnout among academic and administrative staff (Celik & Kose, 2022; Md Shah et al., 2024).

Mental Health Literacy and Awareness Programs

It is crucial to implement mental health literacy programs for both students and staff to increase awareness and reduce the stigma surrounding mental health issues (Gumus & Avci, 2024). These programs should aim to educate the university community on recognizing mental health symptoms and seeking timely help. Workshops on stress management, coping mechanisms, and mental health resilience should be conducted regularly to support both students and staff.

RESEARCH METHODOLOGY

In this study, the qualitative phenomenological approach was employed to collect data by focusing on the lived experiences of individuals at OUM regarding mental health issues. Participants were asked to share their personal experiences and perspectives, allowing the researchers to gain a deeper understanding of how they perceive and make sense of their mental health challenges. This approach aligns with the study's objectives of exploring subjective experiences, providing rich, qualitative insights into the participants' lives. The data collected was then analyzed using Braun and Clarke’s (2006) Thematic Analysis (TA) method, which helped identify common themes across these experiences.

Site, research participants and data collections

The study focuses on undergraduate and postgraduate students, as well as academic and non-academic staff, at OUM campus in Kelana Jaya.

Four focus groups were formed, consisting of two groups for students (undergraduate and postgraduate) and two groups for staff (academic and non-academic). They participated in the semi-structured interview sessions. The formation of four focus groups has facilitated data comparison and triangulation across different participant groups, thereby enhancing the credibility and reliability of the findings (Krueger & Casey, 2015).

When conducting focus group interviews, it is recommended to have at least five or six participants (Krueger & Casey, 2015). Thus, in this study, each focus group discussion involved five to six participants, resulting in 23 participants participating in the focus group discussions. The participants were selected through purposive random sampling based on the following criteria: i) They must be OUM staff or students; ii) Students must be in active status and at least in their second semester; iii) Academic and non-academic staff must have completed a six-month probationary period. Tables 1, 2, 3, and 4 below provide a summary of the participants' backgrounds.

Table 1- Undergraduate Students

Participants' identifications	Alias	Gender	Age
UG Participant 1	UGP1	Female	32
UG Participant 2	UGP2	Male	28
UG Participant 3	UGP3	Female	33
UG Participant 4	UGP4	Male	35
UG Participant 5	UGP5	Female	34
UG Participant 6	UGP6	Female	35

Table 2 - Master's Students

Participants' identifications	Alias	Gender	Age
MS Participant 1	MSP1	Male	38
MS Participant 2	MSP2	Female	45
MS Participant 3	MSP3	Male	53
MS Participant 4	MSP4	Female	47
MS Participant 5	MSP5	Female	54

Table 3 - Academic Staff

Participants' identifications	Alias	Gender	Age
AS Participant 1	ASP1	Male	57
AS Participant 2	ASP2	Female	33
AS Participant 3	ASP3	Male	49
AS Participant 4	ASP4	Female	39
AS Participant 5	ASP5	Male	37
AS Participant 6	ASP6	Male	49

Table 4 – Administrative Staff

Participants' identifications	Alias	Gender	Age
ADM Participant 1	ADMP1	Female	50
ADM Participant 2	ADMP2	Female	44
ADM Participant 3	ADMP3	Female	31
ADM Participant 4	ADMP4	Male	31
ADM Participant 5	ADMP5	Male	38
ADM Participant 6	ADMP6	Male	54

During the focus group interviews, participants were asked to respond to 10 structured questions, along with additional spontaneous follow-up questions posed by the researchers. Their feedback was recorded and carefully transcribed verbatim for further analysis.

Ethical Consideration

Prior to participating in the interview sessions, all participants were required to give their consent. Each participant was given a unique code name during the preparation phase of the research report. Transcriptions and records are carefully encrypted and stored in a secure file.

Data Analysis

The data collected from both exercises were analyzed using the TA method, which consists of six iterative and reflective processes (Nowell et al., 2017). These processes include: first, familiarization; second, generating initial codes; third, identifying themes; fourth, reviewing the themes; fifth, defining the themes; and finally, the sixth phase, which involves composing reports.

Trustworthiness of Data

In qualitative research, the term trustworthiness refers to the validity and reliability of the data presented. This can only be accomplished if the data sources are gathered through various approaches or mechanisms (Shenton, 2004). To fulfill the criteria for trustworthiness—namely, credibility, transferability, dependability, and confirmability as proposed by Lincoln and Guba (1985)—the researchers analyzed the data through careful arrangements, discussions, and documentation. Table 5 below outlines how the trustworthiness criteria were addressed during each phase of TA in this study.

Table 5 - Building Trustworthiness Throughout Every Phase of TA

Phases of TA	Means of Establishing Trustworthiness
Phase 1: Familiarization	Prolong engagement with data Store raw data in well-organized archives
Phase 2: Generating initial codes	Researcher triangulation Audit trail of code generation Documentation of all team meetings
Phase 3: Identifying themes	Researcher triangulation Diagramming to make sense of theme connections Documentation
Phase 4: Reviewing the themes	Researcher triangulation Themes vetted by all team members
Phase 5: Defining the themes	Researcher triangulation Team consensus on themes Documentation
Phase 6: Composing reports	Final checking Report on reasons for analytical choices throughout the entire study

RESEARCH FINDINGS

The recorded and transcribed verbatim from the focus group interviews were analyzed using the TA method. The process began with the researchers immersing themselves in the data by repeatedly listening to the recorded audio, reading the verbatim transcriptions, and reviewing the written responses to grasp the whole meaning of the conversations.

In the second phase of the TA method, the research team members received copies of the transcriptions to identify potential codes. The exercise focused on recognizing words or short phrases that capture the meaning of specific quotes. After some thorough discussions, several codes were identified and arranged in a consistent pattern to form a variety of themes (phase three).

For the first research question (*what are the specific counseling needs of students and staff at OUM?*), the codes and themes were organized as shown in tables 6, 7, 8, and 9 below.

Table 6 - Codes and Themes of Master's Students for the First Research Question

Transcribed verbatim	Codes	Themes
Because when I can't manage or fail to control that time, I will neglect my child... or I will neglect my classes at OUM, or sometimes at work I become unproductive (MSP1) *Maybe time management and how to juggling between my work and also my study at OUM (MSP2)*	Time management	Academic management reconstructed to Navigating academic demand
Because of work... the uncertain hours. Sometimes I work at 2-3 a.m.… during class time, I'm also working…(MSP1)	To balance work and studies' pressure	
My stress level is higher when I am rushing for my assignment, especially during preparation of doing the assignment (MSP2) *Yeah, probably sometimes when we talk about assignment right… (MSP3)*	Submitting assignments	
Maybe when I go for my Internship and practicum, I might face with this situation… (MSP4)	Internships	
Personally, I may need counseling to support in terms of the career side… the career counseling and not so much on mental health (MSP5)	Career path	Career development
I think I may need to have counseling to support in the initial phase of the study…Because during that time maybe I am still in dilemma… whether want to continue study or not (MSP2)	Uncertainty about furthering studies	

Table 7 - Codes and Themes of Undergraduate Students for the First Research Question

Transcribed verbatim	Codes	Themes
It's difficult to divide my time because I'm a housewife. So I need to allocate time for my family, for my husband, and for my mother. I take care of my mother... (UGP1) *I think the most uh serious challenge to me is mainly how to manage time… (UGP2)* *The first one is time management since I'm studying part time and working full time… (UGP3)*	Time management	Academic management reconstructed to Navigating academic demand
My working hours are more than 10 hours… I'm need to travel from home to office, so it almost takes uh 11 to 12 hours per day. It's really hard cope up with the studies and manage the time for studies and everything. Um uh and assignment some more… I mean it's really taken more time for me to finish (UGP3) *Honestly, I haven't started working on the assignment yet because in the past month, I've been quite busy with work and the responsibilities entrusted to me at the company (UGP4)*	To balance work and studies	
Okay… university environment… because now it's fully online study… like UGP5, I used to attend classes before	Study mode	

the lockdown because before the lockdown, everyone had face-to-face classes (UGP4)		
I'm not really positive... I'm not really, uh, how should I put it, motivated to take, uh, I don't believe in myself to take three more courses (UGP5) *I really need this motivational guidance because sometimes, like UGP4 said earlier, I feel the same way… I haven't done any assignments, so when we are in the middle of the semester, I hope there's someone who can motivate us (UGP5)* *It's really hard to keep motivating yourself uh to continue because of the added stress and yeah this is the time that I feel really really hard and I need some support (UGP6)*	Low self-motivation	
Transitioning to university life because the last time I was in university was like 10 years ago (UGP6) *Semester May and September last year were the most difficult in my life since um uh I've lost my father uh due to heart failure (UGP2)*	Personal challenges	Personal challenges
Sometimes we have work, family problems, or sometimes accidents happen… so sometimes from that point, actually… I also have a case where my grandmother was admitted to the hospital for two weeks… so I had to go back and forth from work and then to the hospital… so from that, studying really became out of the question (UGP4)	Family issues	
Also, financial…since uh as you know I'm a working adult… working person uh (UGP2) *Finance issue…like myself… I don't have PTPTN… so I myself pay the tuition fee… so I need to cover everything (UGP3)*	Financial constraint	

Table 8 - Codes and Themes of Academic Staff for the First Research Question

Transcribed verbatim	**Codes**	**Themes**
One of the challenges for academic members is the Final Year Project paper (ASP3)	Students' assignments	
Personally, I don't feel the need to see a counselor, but it's more about the burden of the routine that we have to face every semester (ASP1) *I don't really need to see a counselor, but if we're talking about the workload, it's more about the never-ending deadlines—when one ends, another one begins (ASP2)*	Nonstop deadlines	Academic management reconstructed to Academic workload
My problem was long time ago… When I was transferred to another department, I was left alone without any assistance… There was no instruction… no nothing (ASP4) *The pressure and challenge for me is the miscommunication between departments (ASP3)*	Communication break down	Communication

In my experience of 20 years working, I find that we lack clarity… not understanding the job scope… not knowing the do's and don'ts (ASP6)	Lack of clarity	
There are department heads who do not understand our SOP (ASP3)	Unfamiliar with the standard procedures	

Table 9 - Codes and Themes of Administrative Staff for the First Research Question

Transcribed verbatim	**Codes**	**Themes**
We have heard from some staff who complained to HR that their boss is bullying their subordinates, but no appropriate action was taken; they only changed the department. HR needs to find the root of the problem (ADMP1)	Conflict with the 'bosses'	Work demands reconstructed to Admin work demands
One stress comes from the workload. We cannot escape from doing work (ADMP6) *I feel that sometimes the workload is too much. There was a time when I felt fed up, stressed, and overwhelmed with too much work (ADMP6)*	Heavy workload	
If it's me… because I deal with students. Sometimes I get stressed managing the students (ADMP5) *Stressed with students…It's normal that our students are working adults… we need to handle students in different ways because everyone has different attitudes (ADMP6)*	Stress with students demands	

In the third step of the process, the researchers identified several key themes to better understand the counseling needs of both students and staff at OUM. To ensure the themes were both meaningful and accurately represented the data, the researchers conducted a thorough review. Some themes were refined to enhance their clarity and connection to the participants' quotes. For example, academic management (for master's and undergraduate students) was revised to navigating academic demands, academic management (for academic staff) became academic workload, and work demands (for administrative staff) was redefined as admin work demands.

After completing the review, the researchers concluded that the counseling needs of master's and undergraduate students fell into three main categories: navigating academic demands, career development, and personal challenges. Meanwhile, the counseling needs of academic and administrative staff were grouped into three key areas: academic workload, communication, and admin work demands.

For the second research question (*what are the contributing factors to mental health issues among students and staff at OUM)?*), the codes and themes were organized as depicted in tables 10, 11, 12 and 13 below.

Table 10 - Codes and Themes of Master's Students for the Second Research Question

Transcribed verbatim	**Codes**	**Themes**
My stress level is higher when I am rushing for my assignment, especially during preparation of doing the assignment…Because this semester I took 3 subjects. So now I really feel the stress (MSP2)	Assignment submission - deadline	

Definitely stressful for me especially on the assignment dateline. Because we also having our work, so we have to juggle with our work, family affair, traveling. Because I am from outstation, my parents are from Malacca, so I have to travel (MSP3) *I think I encountered great challenge last semester, because I took 3 subjects where 2 of them were statistic and techniques in counseling. So, I was like… almost die. I can't imagine how I did it. But I have to submit late, because I really don't have time. So that was the peak of my mental health challenge, rushing to submit my assignment on the dateline (MSP5)*		ODL challenges
Another one is the exam time. I don't mind sitting there for many hours I need to, but I don't find enough time to finish all 5 questions. So, I hope that for that 5 questions, I should have been given 10 hours. If less than 5 hours, I prefer to take only 3 questions. Because I really have to type realy2 fast. And then it was really tiring (MSP5) *During my learning sessions…the time I feel critical is during exams. Exams are a crucial time…for example, like today there is one paper, tomorrow there is another paper, and then a day later there is yet another paper. It's quite difficult for me to manage the time (MSP1)*	Final exam	

Table 11 - Codes and Themes of Undergraduate Students for the Second Research Question

Transcribed verbatim	Codes	Themes
I had the opportunity to join face-to-face classes… so I think for me, the face-to-face classes are quite, uh, more interesting to me… um, because we get to meet people… we build a good kind of relationship… but when it comes to online classes… yes, we get to know each other, but I'm not really an extroverted person, so it's hard for me to blend in (UGP5) *Errr… the university environment because now it's fully online study (UGP4)* *When it's online, it's not stress but it's under stress because we don't have the urge to attend classes much… we don't feel like, 'Oh, today I have to go to this (inaudible)'; we don't have that feeling… even if I miss a class, I know I have the link (recording), something like that (UGP1)*	Online environment	ODL challenges
Uh, it's the same regarding the assignment (UGP1) *In between studying and also uh uh with to keep up with the assignment… I need to divide my time in terms of my family and also my work.. (UGP2)*	Assignment submission	

Some more with the assignments mean it's really taken more time for me to finish. Towards end of day it makes me very depressed or either very tired (UGP3)		
From 2016 until now, it hasn't ended because of many extensions… many extensions because of work (UGP4)	Balance between studies and work	
This semester would be the time that I really need counselling and a lot of support because my husband just underwent a surgery and so I have to like take extra care of him you know and everything and right now he's in the recovery process and as we all know the due date for the assignment is like a few weeks away you know and it's really hard to keep motivating yourself uh to continue because of the added stress and yeah this is the time that I feel really really hard and I need some support (UGP6) *I personally for few years back went through a lot of uh anxiety, stress and depression and literally there's no one will talk to me or guide me or motivate me. It's just by myself. I really feel very down until I have a suicidal thought (UGP3)*	Personal issues	Personal challenges
So this one is personally, it's uh the biggest for me and also financially since I'm not.. what is it… eligible to apply for PTPTN, so I have to use my own… deduct part of my salary to pay for the tuition fees (UGP3)	Finance	

Table 12 - Codes and Themes of Academic Staff for the Second Research Question

Transcribed verbatim	**Codes**	**Themes**
The academic challenge in dealing with student issues… I have experienced a student who wanted to harm herself (ASP3) *Student management is indeed challenging (ASP6)*	Managing ODL students	Students' management
The work related to preparing assignment questions and marking final exams… we can't just weigh it lightly… it requires careful consideration, especially for master's students… our time is limited (ASP1) *I agree with ASP1. Preparing assignment questions and marking final exams is indeed challenging (ASP2)* *Marking and preparing assignment questions is indeed challenging, especially for someone like me who is quite meticulous (ASP5)*	Academic workload	Academic management
Managing tutors presents a challenge for me... Sometimes we call them, and they don't respond... unexpectedly, they don't follow the methods we've established (ASP3)	Managing tutors	
We were instructed to change department without our consent (ASP4) *No flexibility… nonstop working (ASP2)*	Work execution	Work management reconstructed to Academic work challenges
KPI is too rigid… no flexibility (ASP3)	KPI challenges	

Table 13 - Codes and Themes of Administrative Staff for the Second Research Question

Transcribed verbatim	Codes	Themes
One of the things you need to know is that every company has a toxic environment. HR should know how to overcome the toxic environment. The shared values are also not properly instilled in the staff (ADMP1)	Toxic environment	Work environment
We don't have any awareness campaign except the mental aiders (ADMP1)	No awareness on mental health	
HR does not help staff regarding mental health issues at all. For example, during KPIs, staff have performed well but are still cut down. If HR can't establish professional counselors, at least they should have a unit for this (ADMP2)	Unclear expectation between staff and HR	

Similar to the process described earlier, the constructed themes were reviewed again to ensure they were both meaningful and accurately reflected the data. As a result of the revision, the researchers agreed to retain all themes for the second research question, with the exception of one. The theme initially labelled work management (for academic staff) was revised to academic work challenges. Following this review, the researchers determined that the key contributing factors to mental health issues among students and staff at OUM are: ODL challenges and personal challenges (for students), and academic management, student management, academic work challenges, and work environment (for staff).

For the third research question (*What policy enhancements can be proposed to improve counseling and mental health services at OUM?*), the codes and themes were labelled as shown in tables 14, 15, 16 and 17 below.

Table 14 - Codes and Themes of Master's Students for the Third Research Question

Transcribed verbatim	Codes	Themes
For me this should be address during the introduction class itself, if there is such a thing available. OUM have many trainings, but nothing about counseling (MSP4) *In my opinion, OUM can promote and prioritize mental health as part of the university's overall policy by promoting it more extensively, similar to how OUM has implemented promotions for the OUM library, for example (MSP1)*	Campaign on counselling services	Proactive campaign reconstructed to health awareness campaign
OUM have the foundation and resources, and what we have for so many years, we can provide such awareness or promotions, and put it as a policy as well (MSP3) *We need to have the policy, and after that we can just do more (MSP4)*	Policy awareness	
To make it available and easily visible, maybe in MyOUM (portal) we can have 'help button' or counseling support button (MSP3)	Accessibility of counseling services	Accessibility of counseling services

Table 15 - Codes and Themes of Undergraduate Students for the Third Research Question

Transcribed verbatim	Codes	Themes
The open day for mental health means that when students have any problems or issues, they can directly walk in on	Policy awareness	

that day to meet with the person in charge regarding the problems they are experiencing (UGP4) *Uh, okay, if I… make sure the policy is known… right now, there is a policy; I'm sure there is a policy, but it is not known or publicized (UGP5)*		Proactive campaign reconstructed to health awareness campaign
Perhaps OUM could provide a platform where we can take tests... like... the tests that are available now, so actually, these tests can also help with mental health (UGP5) *Uh for me I will say we can do uh some survey or mental health test… We just like do uh some survey to test a few students to check their mental level, how they currently being or is there really affected their studies and everything (UGP3)*	Proactive Mental Health Screening	
Providing an online platform is also possible as long as we know who to refer to, but online options are more budget-friendly and easier (UGP1) *Alright uh I think um the university can actively promote and prioritize mental health as part of its institution policies and practices by uh doing a short term seminar that is uh fun, engaging you know… uh we can talk about like how to de-stress or how to manage your time uh anything related to mental health and do it more uh in a fun way so that people would love to come to the seminar every time uh they organize it (UGP6)*	Accessibility of Information	Accessibility of counseling services
Uh, marketing, uh, then social media is now, uh, modern, right? (UGP1)	Use of social media	

Table 16 - Codes and Themes of Academic Staff for the Third Research Question

Transcribed verbatim	**Codes**	**Themes**
Counseling services need to be introduced to all staff (ASP3) *Establish counseling services for staff as well (ASP3)* *It's very urgent… it needs to be established immediately (ASP5)* *It is the role of HR to create this service for staff who need it (ASP6)*	Establishment of counselling services for staff	Counseling services for staff
We need comprehensive counseling services that consider the needs of lecturers (ASP2) *We need inclusive services (ASP5)*	Comprehensive and inclusive counselling services	
Increase accessibility so that everyone knows about the existence of counseling services for staff (ASP2)	Accessibility of counselling services	

Table 17 - Codes and Themes of Administrative Staff for the Third Research Question

Transcribed verbatim	Codes	Themes
By conducting ongoing campaigns about mental health. Or create a channel for you to share about mental health. It doesn't need to be large-scale, but start small (ADMP1) *Sometimes we are just stressed, not necessarily having mental problems. People don't know that overstress can lead to overthinking and affect mental health. There needs to be a campaign to correct perceptions related to mental health (ADMP3)*	Continuous campaign regarding mental health	Proactive campaign reconstructed to health awareness campaign
For the bigger picture, HR can hold talks related to mental health every month. Invite speakers from anywhere to make the talk light and easy for staff to understand. HR should be the main driver for us. So, there needs to be an initial initiative from HR (ADMP2)	HR roles to promote mental health	
Management needs to go down to the field and hold talks or any activities face-to-face with the staff (ADMP6)	Conduct talk	
Like my previous office. Every week, they would pick somebody to share about certain issues. Maybe we could start within the department. Our department is like a family. Sometimes, when we know a friend is unwell, we hesitate to ask (ADMP2)	Sharing session among staff in department	
We must always conduct regular awareness campaigns related to mental health issues. Usually, staff won't share mental health issues because they feel threatened (ADMP6)	Conduct campaign regularly by Management	
The management can also try conducting a mental health survey to assess the mental health needs of the staff (ADMP4)	Conduct survey	

For the third research question, the researchers decided to transform the original "proactive campaign" into a "mental health awareness campaign" while keeping the other two themes, as they accurately reflect the data. These themes were developed in response to the inquiry about policy improvements to enhance counseling and mental health services at OUM. The identified themes are: mental health awareness campaign, service accessibility, and counseling services for staff.

Step 5 in TA method involves defining the themes. This step requires a detailed review of the themes identified in earlier stages to ensure they are coherent, meaningful, and sufficiently distinct. It's essential to clearly define what each theme represents and how it relates to the research question.

The first research question of this study was formulated to identify the specific counseling needs of both students and staff at OUM. Through the analysis conducted in steps 1, 2, 3, and 4 of TA method, the counseling needs of OUM students (both undergraduate and master's level) were categorized into three key themes: navigating academic demands, career development, and personal challenges. The meaning of the constructed themes is described in Table 18.

Table 18 - Definition of Themes for the First Research Question (Undergraduate and Master's Students)

The themes	Definitions
Navigating academic demands	Navigating academic demands focuses on students' struggles with time management, self-discipline, and the challenge of meeting academic expectations in ODL environment. This theme involves specifying how academic stress, workload, and technological barriers uniquely impact ODL students (Hart, 2012)
Career development	Career development encompasses students' concerns about aligning their studies with future career goals. It is important to explore how adult learners return to school, and what motivates them to take on the additional role of being students while balancing numerous other roles and responsibilities (Chu et al., 2007). Understanding this theme would enable counseling providers to address career uncertainty and offer career guidance tailored to the unique circumstances of remote learners.
Personal challenges	Personal challenges involved issues such as mental health struggles, family responsibilities, and the difficulty of balancing work-life demands that affect ODL students during their studies. This theme highlights the unique emotional and psychological challenges faced by students juggling multiple roles in their daily lives, emphasizing the need for tailored support from counsellors (Kember, 1995).

The counseling needs of academic and administrative staff are categorized into three key themes: academic workload, communication, and administrative work demands. The definitions of the themes are shown in Table 19.

Table 19 - Definition of Themes for the First Research Question (Academic and Administrative Staff)

The themes	Definitions
Academic workload	Academic workload refers to the extensive demands placed on academic staff, including course preparation, teaching, grading, student mentoring, and research responsibilities (Razalli et al., 2021). In an ODL context, the workload can be more challenging due to the need to adapt to online teaching methods, provide continuous student support, and manage large cohorts remotely.
Communication	Effective communication is essential in ODL institutions, where much of the interaction between staff, students, and colleagues occurs online (Ahmad Khateeb et al., 2020). Poor communication can lead to misunderstandings, inefficiency, and stress, especially when dealing with remote students or coordinating with other departments. Counseling for communication-related challenges can help staff develop better digital communication skills and reduce the stress associated with virtual environments.
Administrative work demands	Administrative work demands involve the non-teaching responsibilities that academic and administrative staff must manage, such as paperwork, student registrations, data entry, and compliance with institutional policies. In ODL institutions, these demands can be more time-consuming due to the additional technological platforms used for remote operations, creating pressure on staff to manage both academic and administrative tasks effectively (Tait, 2004).

The second research question aimed to explore the factors contributing to mental health issues among students and staff at OUM. Analysis revealed that master's and undergraduate students had identified two key themes: ODL challenges and personal challenges. Meanwhile,

academic and administrative staff highlighted four main themes: academic management, student management, academic work challenges, and the work environment. Tables 20 and 21 explain the details.

Table 20 - Definition of Themes for the Second Research Question (Undergraduate and Master's Students)

The themes	Definitions
ODL challenges	ODL challenges refer to the difficulty's students encounter due to the inherent nature of ODL, which can significantly contribute to mental health issues. These challenges include the absence of face-to-face interaction, feelings of isolation, time management difficulties, and the self-discipline required for independent study (Aboagye et al., 2021).
Personal challenges	Personal challenges refer as individual factors that affect mental health, such as financial stress, family responsibilities, and personal health issues. For ODL students, many of whom juggle multiple roles—such as full-time work or caregiving—these personal challenges can exacerbate the stress of academic life (Bok, 2021).

Table 21 - Definition of Themes for the Second Research Question (Academic and Administrative Staff)

The themes	Definitions
Academic management	Academic management involves overseeing curriculum development, course delivery, and academic performance, which often places staff under pressure due to tight deadlines, high student expectations, and multiple responsibilities. Poorly structured academic management can result in excessive workloads and time pressure, leading to stress and burnout (Van Droogenbroeck at el., 2014).
Student management	Student management presents challenges, as staff must address student needs, provide timely feedback, and resolve conflicts, particularly in an online setting where communication is primarily digital. The high volume of student inquiries can result in stress, frustration, and emotional exhaustion (Tait, 2004).
Academic work challenges	Academic work challenges—such as adapting teaching methods for online platforms, ensuring academic integrity, and managing large virtual classrooms—further increase the workload. These challenges can overwhelm staff, contributing to anxiety, stress, and mental health issues (Kgabo., 2021).
Work environment	Work environment plays a crucial role, as a poorly structured or unsupportive environment, characterized by inadequate communication and limited resources, can intensify stress and lead to burnout (Kinman & Wray, 2018).

The third research question was constructed to examine policy enhancements that can be proposed to improve counselling and mental health services at OUM. For this reason, students and staff have given their views, which were formulated as the following themes: mental health awareness campaigns, service accessibility, and counseling services for staff. Table 22 explains the meaning of the constructed themes.

Table 22 - Definition of Themes for the Third Research Question (Undergraduate Students, Master's Students, Academic Staff and Administrative Satff)

The themes	Definitions
Mental health awareness campaign	Proactive Campaigns refer to organized, ongoing efforts to raise awareness, promote mental health resources, and encourage the early utilization of counseling services among students and staff (Bugshan et al., 2022). Proactive campaigns often include

	workshops, webinars, social media outreach, and educational content aimed at reducing stigma around seeking help and providing guidance on maintaining mental well-being. By taking a preventative approach, these campaigns foster a supportive environment and ensure that individuals are informed about the availability of mental health resources before issues become severe.
Service accessibility	Accessibility of Counseling Services refers to the ease with which students and staff can access mental health and counseling services within the institution. This includes both physical access, such as office locations or virtual platforms, and the availability of timely appointments, multilingual support, and confidentiality assurances. Increased accessibility ensures that individuals facing mental health challenges can seek support without unnecessary barriers, contributing to improved overall well-being (Rickwood & Thomas, 2012).
Counseling services for staff	While student counseling services are commonly emphasized, it is equally important to offer mental health support to academic and administrative staff, who may face unique stressors such as workload pressures, student management issues, and isolation in a remote working environment. Providing targeted counseling services for staff not only supports their mental health but also improves job satisfaction and productivity, which can positively impact the broader institutional culture (Kinman & Wray, 2018).

The first five steps of the TA method led to the conclusion that students' counseling needs can be categorized into three domains: navigating academic demands, career development, and personal challenges. In contrast, the counseling needs of academic and administrative staff were identified within three areas: academic workload, communication, and administrative work demands.

Students reported two main factors contributing to their mental health issues: challenges associated with ODL and personal challenges. Meanwhile, academic and administrative staff highlighted four key factors: academic management, student management, academic work challenges, and the work environment.

To enhance counseling and mental health services at OUM, both students and staff provided suggestions, which can be summarized as follows: mental health awareness campaign, improved service accessibility, and dedicated counseling services for staff.

DISCUSSION

The findings from the research on the counseling needs and mental health issues among students and staff at OUM reflect key challenges that align with existing literature. This discussion synthesizes the research findings with insights from the literature review, examining the counseling needs, contributing factors to mental health issues, and policy recommendations for enhancing mental health services at OUM.

Counseling Needs

Students

The research findings highlight that students at OUM need counseling support to navigate academic demands, career development, and personal challenges. This aligns with Deng et al., 2022, who found that ODL students often struggle to balance their academic workloads with work and family responsibilities. Students face unique pressures from their dual roles as learners and working adults, necessitating counselling services that offer strategies for

managing time, coping with stress, and improving academic performance. Moreover, the findings on career development as a counselling need are consistent with John (2021), who identified that many adult learners require guidance on career transitions, financial management, and personal growth.

Personal challenges such as managing family responsibilities, relationships, and financial stress are also significant, reinforcing the need for holistic counselling services that go beyond academic guidance. ODL students may experience feelings of isolation and lack of peer support (Ng & Lee, 2022), which necessitates counseling interventions that foster social engagement and peer support networks to alleviate these emotional burdens.

Staff

For OUM staff, the findings point to counseling needs related to academic workload, communication, and administrative demands. As Awang et al. (2021) and Razalli et al. (2021) discussed, university staff, especially in ODL institutions, face the challenges of balancing teaching responsibilities with administrative tasks, often leading to job-related stress and burnout. The literature also supports that role overload among academic staff is a common issue (Chakraborty, 2024). Communication issues, both within academic departments and between staff and students, further complicate their ability to manage tasks effectively, adding to their stress.

Counseling services for staff should thus address not only stress management but also professional development in communication and task delegation. Programs focused on improving time management and work-life balance can help staff navigate these challenges.

Contributing Factors to Mental Health Issues

Students

The research findings identify the dual challenges of ODL and personal challenges as key contributors to mental health issues among students. This is consistent with findings by Liu and Lin (2024), who argued that the lack of in-person interaction in ODL settings increases feelings of isolation, anxiety, and depression. The self-directed nature of ODL requires students to develop strong self-management skills, and the pressures to meet academic deadlines while balancing personal and professional responsibilities contribute to heightened stress levels.

The personal challenges faced by OUM students, such as financial stress and family responsibilities, exacerbate these mental health issues. Archuleta et al. (2013) identified financial difficulties as a significant source of anxiety for students, particularly working adults who must balance education expenses with family obligations. Counseling services that address these personal and financial stressors are critical in improving the mental health and well-being of OUM students.

Staff

For OUM staff, mental health issues stem from a combination of academic management, student management, and work environment factors. As noted in the literature, the demands of managing both academic and administrative duties place a heavy burden on staff, leading to emotional exhaustion (Tait, 2004). The need to balance teaching, research, and student management can result in role overload and burnout. Additionally, the work environment in ODL settings, where staff often work remotely or with limited face-to-face interaction, can increase feelings of isolation and professional detachment, contributing to stress and anxiety.

The research findings also point to communication issues within the academic system as a stressor for staff. This aligns with previous studies that identified poor communication and unclear expectations between university administration and academic staff as contributors to workplace dissatisfaction and mental health challenges (Ahmad Khateeb et al., 2020). Effective communication strategies and mental health literacy programs could significantly alleviate these stressors.

Policy Enhancements to Improve Counseling and Mental Health Services

The findings suggest several policy enhancements that could improve counseling and mental health services at OUM. These recommendations are supported by the literature and include proactive mental health campaigns, improved service accessibility, and specific counselling services for staff.

Mental Health Awareness Campaign

The introduction of proactive mental health awareness campaigns, as suggested by the research, is consistent with the literature's emphasis on mental health literacy and awareness. Bugshan et al. (2022) advocated for mental health programs that educate students and staff on identifying symptoms of mental health issues and seeking help. Regular workshops on stress management, time management, and coping strategies can help reduce the stigma around mental health and encourage early intervention.

Service Accessibility

The research findings indicate a need to improve access to counseling services, particularly for students and staff who may not be physically present on campus. Rickwood and Thomas (2012) highlighted the importance of providing accessible counseling services will ensure that individuals facing mental health challenges can seek support without unnecessary barriers, contributing to improve overall well-being of geographically dispersed OUM population. By expanding digital mental health services, for instance, OUM can provide timely and flexible support to both students and staff, addressing their mental health needs more effectively.

Counseling Services for Staff

Finally, the research points to the importance of expanding counseling services for staff, which are often overlooked in favour of student-focused initiatives. As highlighted by Kinman and Wray (2018) staff mental health is a critical area that requires attention, particularly given the high levels of stress and burnout associated with academic and administrative workloads. Offering targeted counseling services, including professional development programs and workshops on work-life balance, could significantly improve staff well-being.

CONCLUSION

The findings from this study reveal that the counseling needs and mental health challenges of students and staff at OUM are deeply intertwined with the nature of open and distance learning and the associated pressures of balancing academic, personal, and professional responsibilities. For students, the primary counseling needs revolve around

managing academic demands, career development, and personal challenges. These needs reflect the unique stressors faced by adult learners in ODL environments, such as juggling work, family, and study commitments. For OUM staff, the counseling needs focus on coping with academic workloads, communication challenges, and the demands of administrative tasks. Staff members often experience role overload and burnout due to the complexities of their roles in ODL settings.

The contributing factors to mental health issues for both students and staff are also well-established. For students, the dual pressures of ODL challenges—such as the need for self-discipline, time management, and coping with isolation—are significant contributors to mental health issues. Personal challenges, including financial stress and family responsibilities, further exacerbate these issues. Similarly, staff members face mental health challenges related to academic management, student management, and the broader work environment, with stressors including role overload, professional isolation, and poor communication within the institution.

To address these mental health challenges, the study proposes several policy enhancements. Proactive mental health campaigns are necessary to increase awareness and reduce stigma, with regular workshops and mental health literacy programs offering valuable support to students and staff. Improving accessibility to mental health services through digital platforms, including teletherapy and online peer support networks, is critical for OUM's geographically dispersed population. Finally, specific counseling services for staff are crucial to addressing their unique stressors, with professional development and work-life balance workshops offering a path to improved well-being.

In conclusion, the study underscores the importance of a comprehensive approach to mental health and counseling services at OUM. By addressing the specific needs of both students and staff and implementing targeted policy enhancements, OUM can create a supportive environment that fosters mental well-being across its community. The integration of proactive mental health initiatives, enhanced accessibility to services, and focused support for staff is vital for reducing the mental health burdens in ODL contexts, ultimately contributing to the overall success and satisfaction of the university's stakeholders.

Funding: This research is supported by Open University Malaysia (Grant number: OUM-IRF-2024-011).
Institutional Review Board Statement: The Ethical Committee of the Open University Malaysia, Malaysia has granted approval for this study on 15 March 2024 (Ref. No. OUM/4.1/371.1(11)/2024).

REFERENCES

Aboagye, E., Yawson, J. A., & Appiah, K. N. (2021). COVID-19 and e-learning: The challenges of students in tertiary institutions. *Social Education Research*, 2(1), 1-8.

Ahmad Khateeb, L., Shdaifat, S.A.K. & Shdaifa, N.A.K. Effectiveness of Communication Techniques in Distance Education and its Impact on Learning Outcomes at Jordanian Universities (Northern Province). *International Journal of Higher Education*, 10(2), 74-82. https://doi.org/10.5430/ijhe.v10n2p74

Archuleta, K. L., Dale, A., & Spann, S. M. (2013). College students and financial distress: Exploring debt, financial satisfaction, and financial anxiety. *Journal of Financial Counseling and Planning*, 24(2), 50–62.

Awang, Y., Mohamed, N., Ahmad, S., & Mohd Nasir, N. (2021). Examining the Influence of Academic and Non-academic Responsibilities on Academicians' Job-related Stress in Higher Education. *Asian Journal of University Education*, 17(4), 498-510. doi:10.24191/ajue.v17i4.16197

Aznira Zainal. (2023). *Pengurusan masa pelajar Kejuruteraan Pendidikan Jarak Jauh (PJJ) di Universiti Sains Malaysia (USM): ke arah pembinaan jadual pengurusan masa pelajar kejuruteraan secara jarak jauh*. Unpublished Master Thesis, Universiti Tun Hussein Onn Malaysia (UTHM).

Bellare, Y., Smith, A., Cochran, K., & Lopez, S. G. (2023). Motivations and Barriers for Adult Learner Achievement: Recommendations for Institutions of Higher Education. *Adult Learning*, 34(1), 30-39. https://doi.org/10.1177/10451595211059574

Bezuidenhout, A. (2015). Implications for academic workload of the changing role of distance educators. *Distance Education*, 36(2), 246–262. https://doi.org/10.1080/01587919.2015.1055055

Bok, G.I. (2021). Adult learners' challenges in distance learning: A case study in Universiti Sains Malaysia. *Issues in Educational Research*, 31(1), 19-36.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bugshan, W.M., Al Qahtani, S.J., Alwagdani, N.A., Alharthi, M.S., Alqarni, A.M., Alsuat, H.M., Alqahtani, N.H., Alqahtani, M.R., Albaqami, T.A.R.A. & Hammad, A. (2022). Role of Health Awareness Campaigns in Improving Public Health: A Systematic Review. *International Journal of Life science and Pharma Research*, 12(6), 29-35. http://dx.doi.org/10.22376/ijpbs/lpr.2022.12.6.L29

Celik, T.Z., & Kose, G. (2022). *Effective Strategies for Managing Workload and Stress*. Yorkville University, Canada.

Chakraborty, K. (2024). Mental Health in The Workplace and Its Effect on Work Life Balance and Health. *International Journal of Creative Research Thoughts (IJCRT)*, 12(1), 1-10

Chu, H.C., Hsieh, M.C. & Chang, S.C. (2007). A Study of Career Development, Learning Motivation, and Learning Satisfaction of Adult. Retrieved from https://files.eric.ed.gov/fulltext/ED504762.pdf

Collings, R., Swanson, V. & Watkins, R. (2014). The Impact of Peer Mentoring on Levels of Student Wellbeing, Integration and Retention: A Controlled Comparative Evaluation of Residential Students in UK Higher Education. *High Educ 68*, 927–942. https://doi.org/10.1007/s10734-014-9752-y

Deng, Y., Cherian, J., Nisa Khan, N. U., Kumari, K., Sial, M. S., Comite, U., Gavurova, B., & Popp, J. (2022). Family and Academic Stress and Their Impact on Students' Depression Level and Academic Performance. *Frontiers in Psychiatry*, 13. https://doi.org/10.3389/fpsyt.2022.869337

Fensie, A., Pierre, T.S., Jain, J. (2024). Engaged learning during distraction: a case study of successful working moms in distance education. *J Comput High Educ*, 36, 389–434. https://doi.org/10.1007/s12528-023-09359-0

Gumus, C.S., & Acvi, D. Relationship between academic teaching staff' mental health literacy levels and beliefs toward mental illness. *Archives of Psychiatric Nursing*, 51, 82-88. https://doi.org/10.1016/j.apnu.2024.05.010

Hart, C. (2012). Factors associated with student persistence in an online program of study: A review of the literature. *Journal of Interactive Online Learning*, 11(1), 19-42.

Inegbedion, J. (2017). Academic Workload Planning for Open and Distance Learning (ODL) Universities: The Experience of National Open University of Nigeria (NOUN). *Open Praxis*, 9(3), 313-333.

John, O. (2021). Counselling Needs of Adult Learners in Adult Education Centres in Enugu Urban. *Journal of Continuing and Development Education*, 1(1), 16-20.

Kamarunzaman, N. Z., Shanthi, A., Md Nen, Z., Zulkifli, N., & Shamsuri, N. I. (2020). Mental Health Issues Among University Students and Educators' Readiness to Detect and Help. *International Journal of Academic Research in Business and Social Sciences*, 10(9). https://doi.org/10.6007/ijarbss/v10-i9/7738

Kelloway, E. K., Dimoff, J. K., & Gilbert, S. (2023). Mental Health in the Workplace. *Annual Review of Organizational Psychology and Organizational Behaviour*, 10(1), 363–387. https://doi.org/10.1146/annurev-orgpsych-120920-050527

Kember, D. (1995). *Open learning courses for adults: A model of student progress*. NJ: Educational Technology Publications.

Kgabo, M.V. (2021). Challenges Experienced by Lecturers in Supporting Students at an Open Distance e-Learning Institution. *Proceedings at BCES Conference Books, 2021, Volume 19. Sofia: Bulgarian Comparative Education Society*.

Kinman, G., & Wray, S. (2018). Presenteeism in academic employees – Occupational and individual factors. *Occupational Medicine*, 68(1), 46-50.

Kirin, A., Ahmad Sharifuddin, Mohd Hisyam Abdul Rahim, Shakila Ahmad, Sharifah Khadijah, & Abdullah Sulaiman. (2021). Impak Pengajaran dan Pembelajaran Secara Online: Kajian Kes Terhadap Pelajar Sekolah Rendah, Menengah dan Universiti Semasa Pandemik Covid-19. *Advances in Humanities and Contemporary Studies*, 2(1), 127-136.

Krueger, R. A., & Casey. M.A. (2015). *Focus Groups: A Practical Guide for Applied Research*. SAGE Publication.

Kumaran, V., Ismail, M., Thinagar, S., & Roslan, S. (2022). Mental Health Disorder among Malaysian Universities Students during COVID-19 Pandemic. *Asian Journal of University Education*, 18(3), 735-744. Doi: 10.24191/ajue.v18i3.18965

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. London: Sage Publications

Liu, Q., & Lin, D. (2024). The Impact of Distance Education on the Socialization of College Students in the Covid-19 Era: Problems in Communication and Impact on Mental Health. *BMC Medical Education*, 24(1), 575. https://doi.org/10.1186/s12909-024-05551-7

McMaster, R., Adachi, K., Yada, H., Odachi, R., Omura, M., & Cleary, M. (2021, March 19). Exploration of Mental Health Issues of Students among University Health Science Academics in Japan. *Issues in Mental Health Nursing*, 42(9), 862–869. https://doi.org/10.1080/01612840.2021.1894617

Md Shah, S., Noranee, S., Abdul Munir, Z., Noranee, S., Shahruddin, S. & Mujanah, S. (2024). The Influence of Work-Life Balance, Workload and Work Environment on Burnout among Teachers in Melaka Tengah District, Malaysia. *Information and Business Management Review*, 16(1), 137-152.

Mohamad, A., M. (2022). The Implementation of Online Teaching and Learning While In Movement Control Order: Analysis Of Issues And Problem. *Sains Humanika*, 15(1), 33-46. DOI: https://doi.org/10.11113/sh.v15n1.1953

Ng, S.K., & Lee, C.S. (2022). Student Engagement and Perceived Academic Stress: Open Distance Learning in Malaysia. *Proceedings in 35th AAOU Annual Conference 2022 (Jeju-do, Korea) At: Jeju-do, Korea.*

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, 16, 1–13. https://doi.org/10.1177/1609406917733847

Pointon-Haas, J., Waqar, L., Upsher, R., Foster, J., Byrom, N., & Oates, J. (2023). A systematic review of peer support interventions for student mental health and well-being in higher education. *BJPsych open*, 10(1), e12. https://doi.org/10.1192/bjo.2023.603

Razalli, A. R., Kamaruddin, K., Tek, O. E., Teck, K. W., & Daud, N. A. M. (2021). Evaluating Teaching Workload of Academic Staff for Optimum and Effective Use of Expertise Resources. *International Journal of Academic Research in Business and Social Sciences*, 11(6), 13–26. http://dx.doi.org/10.6007/IJARBSS/v11-i6/10077

Rickwood, D., & Thomas, K. (2012). Conceptual measurement framework for help-seeking for mental health problems. *Psychology Research and Behavior Management*, 5, 173–183.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22(2), 63-75. https://doi.org/10.3233/EFI-2004-22201

Tait, A. (2004). Management of services to students. In A. Tait & R. Mills (Eds.), *Rethinking Learner Support in Distance Education: Change and Continuity in an International Context*. USA: Routledge.

Tobia, L., Vittorini, P., Di Battista, G., D'Onofrio, S., Mastrangeli, G., Di Benedetto, P., & Fabiani, L. (2024). Study on Psychological Stress Perceived among Employees in an Italian University during Mandatory and Voluntary Remote Working during and after the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, 21(4), 403. https://doi.org/10.3390/ijerph21040403

Van Droogenbroeck, F., Spruyt, B., & Vanroelen, C. (2014). Burnout among senior teachers: Investigating the role of workload and interpersonal relationships at work. *Teaching and Teacher Education*, 43, 99–109. https://doi.org/10.1016/j.tate.2014.07.005

Williams, G., Thomas, K., & Smith, A. P. (2017). Stress and Well-Being of University Staff: An Investigation Using the Demands-Re-sources-Individual Effects (DRIVE) Model and Well-Being Process Questionnaire (WPQ). *Psychology*, 8, 1919-1940. Doi: 10.4236/psych.2017.812124

BRIDGING CAMPUS ENGAGEMENT WITH VIRTUAL REALITY (VR): A STUDY ON WOMEN'S ACCEPTANCE OF VR CAMPUS TOUR IN AN OPEN UNIVERSITY

Myra C. Almodiel[A], Anna Ma. Elizabeth Cañas-Llamas[B], Marinela S. Hernandez[C], Anna Mhari C. Duria[D], Zyrene Edrei M. Villanueva[E]

ABSTRACT

Immersive technological advances such as Virtual Reality (VR) is reshaping the landscape of the educational system as universities strive to adapt to changing student demographics and evolving technological trends in this era defined by digital innovations and global connectivity. As virtual engagement becomes increasingly important, more universities are adopting VR-enhanced campus tours to extend their outreach and foster deeper connections with a broader audience. Recognizing the potential of VR, UP Open University (UPOU) has embarked on the learning innovation of developing the UPOU Virtual Campus Tour as part of the university's commitment to the Sustainable Development Goal of providing inclusive and equitable education while promoting lifelong learning opportunities for all. This study evaluates the perspectives, experiences and user acceptance of the UPOU Virtual Campus Tour among women at UPOU. The research aims to show how women in an open university context perceive and interact with VR technology. The findings will offer valuable insights and putting women's voices into the factors influencing user acceptance of VR in educational settings, contributing to a deeper understanding of the potential and challenges of implementing VR in Asian open universities.

Keywords: *Virtual Reality, Technology Acceptance, Lifelong Learning, Gender Equality, Open University*

INTRODUCTION

Immersive technological advances such as Virtual Reality (VR) is reshaping the landscape of the educational system as universities strive to adapt to changing student demographics and evolving technological trends in this era defined by digital innovations and global connectivity.

The traditional methods of campus tours, which have long been recognized as pivotal in offering a firsthand glimpse into the university experiences, are being reimagined

[A] *Doctor of Communication, University of the Philippines Open University, Philippines Email: myra.almodiel@upou.edu.ph Orcid: https://orcid.org/0000-0001-7062-7931*

[B] *Bachelor of Science in Development Communication, College of Development Communication, University of the Philippines Los Baños, Philippines. Email: anna.canas@upou.edu.ph*

[C] *Bachelor of Science in Mathematics and Science Teaching, Institute of Mathematics, College of Arts and Sciences, University of the Philippines Los Baños, Philippines. Email: mshernandez8@up.edu.ph*

[D] *Bachelor of Secondary Education Major in English, College of Teacher Education, Southern Luzon State University, Philippines. Email: annamhari.duria@upou.edu.ph*

[E] *Bachelor of Science in Development Communication, College of Development Communication, University of the Philippines Los Baños, Philippines. Email: zyreneedrei.villanueva@upou.edu.ph*

worldwide and is undergoing a profound transformation,

At the forefront of this evolution lies the emergence of virtual tours, offering an immersive and interactive experience that transcends the limitations of physical proximity.

Recognizing the potential of VR, UP Open University (UPOU) has embarked on the learning innovation of developing the UPOU Virtual Campus Tour as part of the university's commitment to the Sustainable Development Goal of providing inclusive and equitable education while promoting lifelong learning opportunities for all.

While innovation and technological change are deep shifts reshaping life in the twenty-first century, we must ensure that technology amplifies women's voices so that they may have a stronger impact on the future course of our world…to ensure that the technology of our future fosters sustainability and inclusion...as bringing women's perspectives into science and technology will help the sector to understand that innovation needs to extend beyond the purely technical...in every sphere, women's rights and contributions are vital for a future where technology serves humanity, not the other way around (Bahous, 2023).

In a world where technology design has been dominated by male perspectives, leading to unintentional bias in user experiences, studying women's perceptions, experiences, and acceptance of virtual reality (VR) is essential for identifying gender-specific preferences and creating more equitable and user-friendly technologies.

This study focuses on women perspectives and their experiences and acceptance of the UPOU Virtual Campus Tour at UPOU. The research aims to shed light on how women in an open university context perceive and interact with VR technology. The findings will offer valuable insights into the factors influencing user acceptance of VR in educational settings, contributing to a deeper understanding of the potential and challenges of implementing VR in Asian open universities. By exploring these experiences, the study seeks to enrich the existing literature and guide future research on VR-enhanced educational tools.

Research Objectives

In general, this study aims to determine the user acceptance and perceptions of female students and staff of UPOU on the use of the UPOU Virtual Reality Campus Tour as an innovative tool in showcasing the programs and services of the university.

Specifically, this study aimed to answer the following questions:

1. What are the experiences of women at UPOU in using VR?
2. How acceptable is the UPOU VR Campus tour in terms of its usefulness and ease of use among women?
3. How do the women at UPOU intend to use the UPOU VR Campus tour?
4. What are the perceived best and least qualities of the UPOU VR Campus tour among women at UPOU?
5. What are the perceived benefits and disadvantages of using the UPOU VR Campus tour among women at UPOU?

LITERATURE REVIEW

The virtual tour is defined as a simulation of a real place that often includes multimedia such as images, text, sound effects, and video clips, a reproduction of actual location with the help of consecutive still images that can help in renewing a realistic presentation of reality (Bakre et al, 2017, Alenazi & Demir, 2019).

VR Campus Tours offer a simulated experience of a university campus through immersive and interactive technologies. Virtual tours offer an immersive and interactive experience allowing prospective students to explore the campus at their own pace and from the comfort of their homes (Khan, 2023). These tours allow prospective students to explore the campus virtually, including facilities, student life, and academic resources.

Virtual tours mimic the real world with computer generated environment and increase engagement of users with the enhanced Virtual Reality technology, and have become a popular way of travelling through space or time, providing an alternative way to the potential student and parents to conveniently tour the campus without coming to the physical building of the university (Rohizan, etal, 2020). By offering comprehensive views and detailed information about campus facilities and programs, exploring the campuses from afar for those who are unable to visit physically is made possible through the virtual campus tours.

In 2021, Emily Bamforth (edscoop.com) wrote an article about how virtual tours are catching on in higher education. “Demand for virtual tours boomed during the pandemic…” “Virtual college tours became a staple during the coronavirus pandemic with a jump of 258% in participation among high school seniors.” In addition, Ajuha (2023) shared in his article that 360 virtual tours increase engagement by 40%, users spend five to ten times longer on websites with virtual tours, and 67% of surveyed consumers say that virtual tours positively influence their decision to avail of offered products.

Recent studies showed that with the advent of technology, virtual tours have emerged as a compelling alternative, complementing traditional methods and expanding the reach of campus exploration.

Universities worldwide are embracing virtual tours as a strategic tool to broaden their outreach and cater to diverse audiences. Virtual tours allow users to visualize and explore the campus environment, which can have a significant impact on them in making the final decision about which campus to choose to pursue their studies (Suwarno & Murnaka, 2020).

Preliminary findings in a pilot project utilizing a VR photo-based tour as an alternative to International Christian University (ICU)’s traditional physical campus tours indicate that spatial presence in the virtual tour caused participants to feel more interested in the university and in actually visiting the campus (Figueroa, et al, 2020).

A study by Suwarno and Munarka (2020) revealed that the use of virtual reality provides another alternative as a campus promotion media by providing an in-depth experience for users to quickly get around without having to visit the campus physical building of Bina Nusantara University in Indonesia.

Considering the vast potential virtual campus tours present, it is critical to look into user experience and acceptance of the UPOU VR campus tour among its users, especially among women, to ensure the successful implementation of this technology.

User experience and acceptance plays an important role in the success of virtual tours because the platforms should deliver the services for user satisfaction in terms of its user-friendliness and ease in navigation (Rohizan, etal, 2020)

THE UPOU VIRTUAL REALITY (VR) CAMPUS TOURS

The University of the Philippines Open University (UPOU) is one of the constituent units of the country's national university and the leading provider of distance education in the Philippines.

The UPOU VR Campus Tour is one of the initiatives of the university designed to explore the concept of immersive learning environments and integrate cutting-edge technologies for disseminating information to UPOU stakeholders and the broader public. Through the UPOU VR Campus Tour, the university hopes to promote further lifelong learning opportunities and reach a wider and broader range of audiences in the Philippines and worldwide.

The UPOU VR Campus Tour is a project initiated by the UPOU Office of Public Affairs (OPA) in coordination with the UPOU Center for Open and Digital Teaching and Learning (CODTL). The VR campus tour was in-house developed using the 3D Vista Virtual Tour software by Open and Digital Learning Research team headed by Dr. Roberto Figueroa, Jr., as part of the university's Immersive Open Pedagogies (IOP) program to provide an alternative way to promote the university's programs and initiatives, irrespective of geographical constraints (see Figure 1).

Figure 1 – Screenshot of the UPOU VR Campus Tour
Source: UPOU Website https://iop.upou.edu.ph/vrtours/upouvr/alpha/

The UPOU VR campus tour served as a vital component of the university's public service endeavors in facilitating benchmark meetings, in-person visits of institutions, trainings, and educational exhibits, as part of the university's commitment and dedication to inclusive and equitable education.

The UPOU VR campus tour is now being used to showcase the university's programs and services and can be accessed through this URL: https://iop.upou.edu.ph/vrtours/upouvr/alpha/. The UPOU VR Campus tour can also be used as a stand-alone application and can be downloaded for offline use, facilitating offline access for individuals seeking to explore the UPOU campus at their convenience.

DATA AND METHODOLOGY

This study used the survey research method to determine the experience and perceptions of students and staff of UPOU in using the UPOU VR Campus Tour. UPOU staff and student assistants who are based at the UPOU main campus were invited to try the alpha version of the UPOU Campus VR Tour using the Oculus. Using Google Form, an online questionnaire based on the Technology Acceptance Model was used as the main gathering tool to measure the perceived usefulness, perceived ease of use, and intent to use UPOU VR Campus Tour among student assistants and staff of UPOU.

In addition, respondents were asked to enumerate what they like best and least about the VR campus tour and their perceived benefits and advantages of using VR-enhanced campus tours using open-ended questions.

Conceptual Framework

The Technology Acceptance Model (TAM), based on the Theory of Reasoned Action (TRA), is one of the most frequently used models to determine the users' acceptance or rejection of a particular technology. User acceptance is often the pivotal factor determining the success or failure of an information system project (Davis, 1993). TAM "provides an informative representation of the mechanisms by which design choices influence user acceptance, and should therefore be helpful in applied contexts for forecasting and evaluating user acceptance of information technology (Davis, 1993)". Furthermore, Davis (1993) specifies the causal relationships between systems design features, perceived usefulness, perceived ease of use, intent of use, and actual usage behavior.

Davis (1989) mentioned two important determinants that may influence the user to use a particular system. These two variables are the perceived usefulness and the perceived ease of use. Perceived usefulness (PU) is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). On the other hand, perceived ease-of-use (PEOU) is defined as "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989).

This study will use the framework based on TAM (see Figure 3) to explore how UPOU staff and students perceived the use of VR campus tours as an innovative tool in showcasing the programs and services of the university.

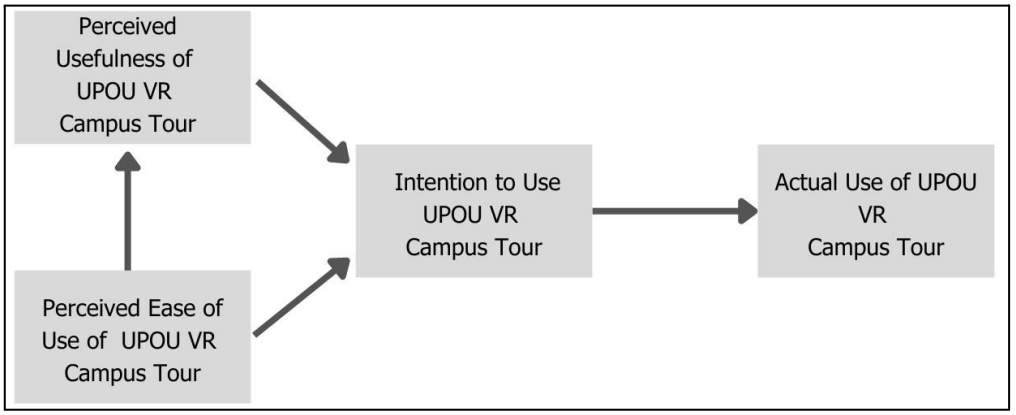


Figure 3 – Theoretical Framework on the Use of UPOU VR Campus Tour

Participants

A total of 31 respondents composed of female staff and students were included in this study. Most of the respondents (90.324%) are between 18-40 years old, and more than half (58.06%) of the respondents are eyeglasses dependents.

RESULTS AND DISCUSSION

Experience in using VR

Among the respondents, seventy percent (70.93%) have prior experience in using 360 degrees or videos while more than half (58.06) have prior experience in using VR. Many (64.52%) of the respondents experienced cybersickness (such as dizziness, headache, eye, and fatigue) while using the VR tour.

Perceived usefulness

To determine the respondents' perception on the usefulness of VR campus tours, the scores for the four statements (Q1 to Q4) were recorded and measured. Results in Table 1 showed that most of the respondents agreed that using virtual reality (VR) technology to conduct campus tours. Specifically, most of the respondents agreed on the statements that the VR "would improve my ability to effectively showcase the campus to prospective students" (90.3 percent), "would allow me to provide a more immersive and engaging experience for prospective students" (93.55 percent), "would help me to better highlight the unique features and offerings of our campus." (95.55 percent), and "would make it easier for me to answer questions from prospective students about the campus" (90.32 percent). On the other hand, only one respondent disagreed with the statement "VR technology would help me to better highlight the unique features and offerings of our campus".

Table 1 – Perceived usefulness of UPOU VR Campus Tour

	Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Q1	Using virtual reality (VR) technology to conduct campus tours would improve my ability to effectively showcase the campus to prospective students.	0.00%	0.00%	9.68%	38.71%	51.61%	4.42
Q2	Using VR technology would allow me to provide a more immersive and engaging experience for prospective students.	0.00%	0.00%	6.45%	41.94%	51.61%	4.45
Q3	Using VR technology would help me to better highlight the unique features and offerings of our campus.	0.00%	3.23%	3.23%	45.16%	48.39%	4.39
Q4	Using VR technology would make it easier for me to answer questions from prospective students about the campus.	0.00%	0.00%	9.68%	45.16%	45.16%	4.35

Perceived ease of use

To determine the respondents' perception of the ease of use of VR campus tours, the scores for the four statements (Q5 to Q8) were recorded and measured. Results in Table 2 showed that most of the respondents agreed that "virtual reality (VR) technology easy to understand and use" (83.87 percent), respondents were able to "easily navigate through the VR campus tour environment" (83.87 percent), "VR campus tour controls were intuitive and easy to use" (87.10 percent), and respondent "was able to quickly learn how to use the VR technology to explore the campus" (90.32 percent). On the other hand, one respondent disagreed with the statement that she "was able to quickly learn how to use the VR technology to explore the campus".

Table 2 – Perceived Ease of Use of UPOU VR Campus Tour

	Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Q5	I found the virtual reality (VR) technology easy to understand and use.	0.00%	0.00%	16.13%	41.94%	41.94%	4.26
Q6	I was able to navigate through the VR campus tour environment easily.	0.00%	0.00%	16.13%	38.71%	45.16%	4.23
Q7	The VR campus tour controls were intuitive and easy to use.	0.00%	0.00%	12.90%	38.71%	48.39%	4.35
Q8	I was able to quickly learn how to use VR technology to explore the campus.	0.00%	3.23%	6.45%	38.71%	51.61%	4.39

Intent to use

To determine the respondents' intention to use the VR campus tours, the scores for the statement (Q9) were recorded and measured. Results in Table 3 showed that most respondents agreed that they "intend to use VR Tour to serve as a valuable resource for the UPOU Community" (90.32 percent).

Table 3 - Intent to use the UPOU VR Campus Tour

	Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Q9	I presently intend to use VR Tour to serve as a valuable resource for the UPOU Community.	0.00%	0.00%	9.68%	22.58%	67.74%	4.58

CONCLUSION

A VR campus tour in a university opens up new opportunities and ways to expand campus engagement by enabling students and prospective students to explore the campus, eliminating geographical barriers through immersive technologies.

The findings of the study revealed that most of the women at UPOU who experienced using the UPOU VR campus tour agreed that virtual reality (VR) technology is "easy to understand and use," and can be "easily navigated through the VR campus tour environment," that "VR campus tour controls were intuitive and easy to use" and respondent "was able to quickly learn how to use the VR technology to explore the campus."

In terms of ease of use, results showed that most of the respondents agreed that "virtual reality (VR) technology easy to understand and use," VR can be "easily navigated through the VR campus tour environment," "VR campus tour controls were intuitive and easy to use," and respondents were "able to quickly learn how to use the VR technology to explore the campus.".

Results also noted the respondents' perception of the best and least characteristics and the benefits of using the VR campus tour.

Overall, most respondents have high acceptance scores regarding the UPOU VR campus tour's usefulness and ease of use. Moreover, respondents indicated that they intend to use it as a valuable resource to showcase the university's programs and services.

Understanding the women's perspectives, experiences and acceptance on the VR tour indicated in the results of this study will help to further improve the UPOU VR Campus tour, making sure that women's voices are heard in the implementation of ths technology.

REFERENCES

Alenazi, M., & Demir, F. (2019). Understanding virtual reality tours: a user experience study with the princess Norah University. *International Journal of Current Research in Life Sciences*, 8(10), 3248-3253.

Bahous, S. (2023). Technology and gender equality—Bringing women and girls to the centre of innovation. United Nations Women. https://www.unwomen.org/en/news/stories/2023/05/technology-and-gender-equality-bringing-women-and-girls-to-the-centre-of-innovation

Bamforth, E. (2021) 'EnTribe' CEO says universities want 'authentic' community engagement. *EdScoop Higher Education* https://edscoop.com/entribe-university-student-engagement/

Davis, F. (1993). User Acceptance of information technology: system characteristics, user perceptions and behavioral impacts. *Index of Learning Styles (ILS). WWW* Page. URL http://deepblue.lib.umich.edu .

Figueroa, R. B., Mendoza, G. A. G., Fajardo, J. C. C., Tan, S. E., Yassin, E., & Thian, T. H. (2020). Virtualizing a university campus tour: a pilot study on its usability and user experience, and perception. *International Journal in Information Technology in Governance, Education and Business*, 2(1), 1-8.

Osman, A., Iskak, N. I., Wahab, N. A., & Ibrahim, N. (2020). Interactive virtual campus tour using panoramic video: a heuristic evaluation. *Journal of Computing Research and Innovation*, 5(4), 1-7.

Rohizan, R. B., Vistro, D. M., Puasa, M. R. B. (2019, May). Enhanced visitor experience through campus virtual tour. *In Journal of Physics: Conference Series* (Vol. 1228, No. 1, p. 012067). IOP Publishing.

Suwarno, N. P. M., & Murnaka, N. (2020). Virtual Campus Tour (Student Perception of University Virtual Environment). J. Crit. Rev, 7, 4964-4969.

UP Open University, 2023. UPOU Showcases Virtual Reality Projects in SyenSaya Booth. https://www.upou.edu.ph/news/upou-showcases-virtual-reality-projects-in-syensaya-booth/

Tahir, M., Shaikh, M., Khan, M., Zaki H., Khan A., (2023) Virtual 3D Tour: A User Experience for On-Campus Orientation. *Pakistan Journal of Scientific Research*. doi: https://doi.org/10.57041/pjosr.v3i1.949

ANALYZING THE ACCEPTANCE OF COLLABORATIVE LEARNING TOOLS AMONG ONLINE STUDENTS USING THE TECHNOLOGY ACCEPTANCE MODEL

Jia Paladin Billones[A]

ABSTRACT

Information and Communication Technologies, such as collaborative learning tools, were used in educational institutions to alleviate geographical restrictions and facilitate easier collaboration in education. This study used the Technology Acceptance Model (Davis, 1989) to investigate the relationship between online students and their use of collaborative learning tools using a semi-structured survey questionnaire using Google Forms. A convenience sampling technique was used to identify the target participants, and the data from the 67 respondents were analyzed using a combination of data analysis methods. Results showed that online students' Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude Toward Using (AT), and Behavioral Intention to Use (BI) positively influence each component that predicts and confirms the Actual Usage (AU) of collaborative learning tools. Among the six types of collaborative learning tools, the most used is communication, and the least used is consensus building. For advantages, three themes were established from the online students' responses: workflow, usability, and social. For disadvantages, there are four themes established from the responses of online students: workflow, technical, usability, and none. There are concerns regarding the accessibility and usability of the general collaborative learning tools. This study recommended investigating the workflow and usability concerns about using collaborative learning tools as it further understands the user experience (UX) and Human-Computer Interaction (HCI), as not all students can keep up before developing learning technologies that guarantee their improved usage.

Keywords: *Collaborative Learning Tools, Online Education, Online Student Experience, Technology Acceptance Model, Human-Computer Interaction*

INTRODUCTION

Information and communication technologies, such as collaborative learning tools, were used in educational institutions to alleviate geographical restrictions and facilitate easier collaboration in essential educational activities in an online setting. In the 21st century, collaboration is one of the 4Cs learning skills to possess. Such skills significantly influence us not only as students but also prepare students to succeed in future endeavors since the ability to work in groups is a requirement for the workplace in this modern day (Lowes, 2014). Raja and Nagasubramani (2018) mentioned that ICT increased education access, allowing collaborative and cooperative learning even mediated by distance. Furthermore, ICT developments resulted

[A] *Undergraduate Student, Faculty of Information & Communication Studies, University of the Philippines Open University, Laguna, Philippines. Email: jpbillones1@up.edu.ph Orcid: https://orcid.org/0009-0003-0155-0354*

in products such as collaborative learning tools that alleviate geographical restrictions and facilitate easier collaboration in education.

Just like any other tool, collaborative learning tools intend to enhance the experience. Conversely, this notion varies from student to student, depending on their abilities and background. This study aims to better understand online students' perceptions of collaborative learning tools.

Statement of the Problem

This study used the Technology Acceptance Model to investigate the Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI), and Actual Usage (AU), their relationship, the acceptance, and the use of collaborative learning tools among online students. Specifically, this study aimed to answer the following questions:

1. What are the socio-demographics of the online students in this research?
2. What are the Online students' Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI) and Actual Usage (AU) of Collaborative Learning Tools?
3. What is the relationship between online students' Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI) and Actual Usage (AU) of Collaborative Learning Tools?
4. What is the actual usage of collaborative learning tools among online students?
5. What are the perceived advantages and disadvantages of collaborative learning tools among online students?

LITERATURE REVIEW

This section discussed the status of online learning in the 21st century, collaborative learning tools, the Technology Acceptance Model (TAM), and theoretical and conceptual frameworks. It elaborated on the background, context, and gaps concerning the objectives.

Online Learning in the 21st Century

Online learning is synonymous with web-based education, e-learning, and distance education but is generally defined as a bridge for student-teacher interaction through web-based technologies (Singh & Thurman, 2019). The study of Elango et al. (2008, as cited in Ayu, 2020) highlights that the Internet is the only way to pass through barriers regarding access to education. Applying these technologies allows students to learn anything, anytime, anywhere – accurately depicting a 21st-century learner.

Collaborative learning is one of the essential activities in a conventional classroom that is now feasible online. Gilbert (2015) also revealed that students who are accomplishing general activities already face challenges when they are done online. Thus, working in groups online is more susceptible to hindrances as it involves more than two elements: other students and their constraints. Despite the challenges, online learning tools alleviate such situations. According to the study of Robinson et al. (2017), there are innate benefits and challenges to these online learning tools, but the key is understanding the proper usage.

Collaborative Learning Tools Used

Concerning online learning tools, Wardlow & Harm (2015) revealed collaborative activities performed online, such as editing, discussion, brainstorming, data collection, and task management, alongside its example resource tools. The study by Sawant (2021) categorized these types of tools into 11 classifications, from brainstorming to content development. Another classification of online collaborative tools is introduced into five categories: video conferencing, collaborative writing applications, digital whiteboards-cork boards, wikis, and social bookmarking (Rhoads et al., 2018). As Carnegie Mellon University (2009) discussed the collaboration tools, it also mentioned the following types: communication (virtual meetings, video conferencing, discussion boards, etc.), project management (task management, time tracking, calendaring, etc.), resource management (file storage, access management, social bookmarking, etc.), ideation & co-creation (concept mapping, virtual whiteboards, real-time collaborative editing, etc.), consensus building (polling, question management, process archiving, etc.), and presentation & archiving (webinars, slideshows, hosted media sharing, etc.) All these studies identified and classified online learning tools used for collaboration. Overall, the types and exemplification of the online learning tools mentioned above will be the basis for further investigating their relationship with online students from the University of the Philippines Open University (UPOU).

Technology Acceptance Model (TAM) by Davis (1989)

Studies on understanding collaborative learning tools in distance education also utilized the Technology Acceptance Model. Davis (1989) described this model as predicting user intention towards technology. It also covers determining perception regarding specific technology usage. Although there are several modifications and newer versions, the original model investigates the primary determinants, Perceived Ease of Use (PEOU) and Perceived Usefulness (PU), that affect an individual's intention to use a new technology. Perceived Ease of Use (PEOU) refers to users' effort towards the technology. Perceived Usefulness (PU) denotes how the user believes that using the technology introduced improves performance. Other constructs include Attitude Towards Usage (AT), which captures the emotion or sentiment of users; Behavioral Intention (BI), which measures the cognitive likelihood to act; and Actual Usage (AU), which shows the final and observable outcome of technology usage. Granić and MarangunićIt (2019) highlighted the determinants of Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) indeed affect the acceptance of learning through a certain technology as studied in 71 primary papers between 2003 and 2018. Baharin et al. (2015) utilized the Technology Acceptance Model (TAM) to analyze the effectiveness of Interactivity Distance Education Web Learning (IDEWL) as an Education Web Learning platform with a modification of an additional variable, system interactivity. Also, a study by Cheung and Vogel (2013) utilized the same model for collaborative technologies, specifically Google Applications. Wu & Chen (2017) focused on the relationship between the determinants of students and Massive Open Online Courses (MOOCs), which resulted in positive and negative influences with strong and weak associations.

Theoretical Framework

The Social Development Theory of Lev Vygotsky is one of the most prominent theories used in learning, specifically, understanding mediated learning. Social Development Theory suggests that social interaction is essential to cognitive development. It emphasized that social contribution enables enriched learning by establishing a common ground for people (or learners). The study of Wardlow and Harm utilized this theory to understand how digital tools overcome barriers to enhance collaborative learning in classrooms. In this sense, collaboration directly impacts better functioning cognitive. The following figure presents the Zone of Proximal Development and Scaffolding Theory related to Social Development Theory. It denotes the ease of learning for more learners with knowledgeable people and technology/tools (McLeod, 2023).

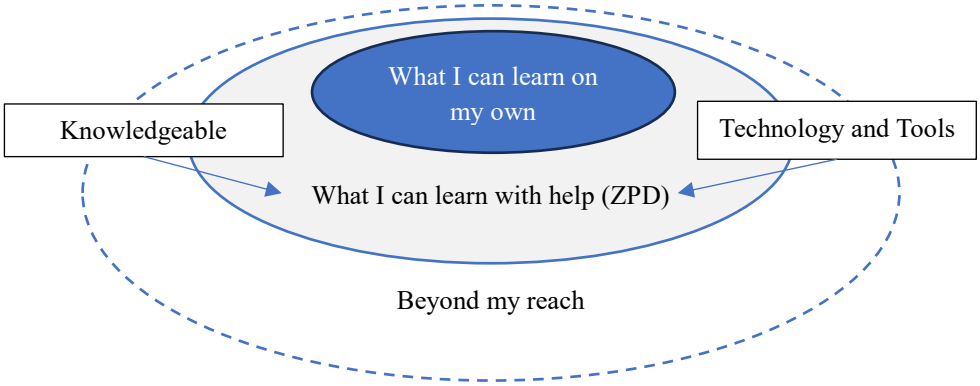


Figure 1 – Vygotsky's Zone of Proximal Development (ZPD) and Scaffolding

Conceptual Framework

This study employs the Technology Acceptance Model by Davis (1989). Generally, the Technology Acceptance Model is an influential and frequently used model to analyze individuals' acceptance through their perception of an information system (Chaudhari, 2023). Davis (1989) enumerated the determinants in the Technology Acceptance Model: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude Towards Usage (AT), Behavioral Intention to use (BI), and Actual Usage (AU). In this study, the following illustrates the relationship between the mentioned determinants that affect the acceptance of online students on Collaborative Learning Tools (CLTs):

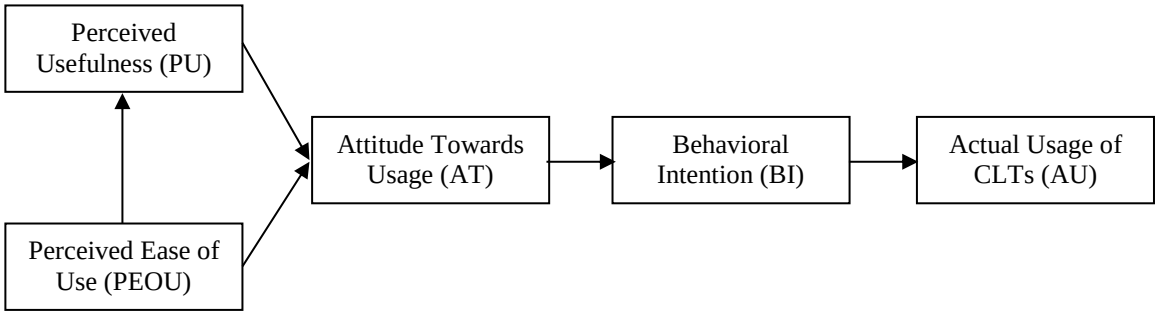


Figure 2 – Technology Acceptance Model (TAM) (Davis, 1989)

DATA AND METHODOLOGY

This section discussed the study's approach to addressing the research question. The following described the research design, instrumentation, units of analysis, sampling, data collection, and data analysis.

Research Design

This study utilized the Technology Acceptance Model (TAM) (Davis, 1989) to determine the online students' acceptance and use of collaborative learning tools. It analyzed the relationship between the Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Toward Usage (AT), Behavioral Intention (BI), and Actual Usage (AU) of collaboration tools among online students. It also determined the perception of online students of the advantages and disadvantages of collaborative learning tools.

Instrumentation, Units of Analysis, and Sampling

This study used a semi-structured survey questionnaire using Google Forms to determine the online students' acceptance and use of collaborative learning tools. There was a total of 33 questions divided into seven sections: an overview of the research project and data privacy, demographic attributes of respondents, collaborative learning tools and their types, modified questions from the Technology Acceptance Model, the specific usage of respondents for collaborative learning tools ranking and mainly used applications/websites for each type, the advantages and disadvantages of using collaborative learning tools. The respondents for this study were 67 undergraduate students from the University of the Philippines Open University. This study used the convenience sampling technique.

Data Collection and Data Analysis

The first task was to draft a questionnaire following the Technology Acceptance Model (TAM), which the research adviser validated. After approval, the researcher input the questionnaire and the consent agreement into Google Forms. The researcher sent the survey questionnaire to different platforms accessible by the University of the Philippines Open University (UPOU) students, including direct and group conversations on social networking sites, MyPortal messaging, and e-mail. A total of 67 responses were received.

This study used descriptive analysis for socio-demographics, the online students' Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI), and Actual Usage (AU) of collaborative learning tools. Reliability analysis further validated the modified TAM questionnaire. Cronbach's Alpha (1951) is a method to measure the reliability of the instrument construct. Tavakol and Dennick (2011) mentioned that 0.70 to 0.95 (or 0.90) are acceptable Alpha values. Whether too low or too high, omitting these items increases the instrument's reliability. Correlation analysis was utilized to evaluate the correlation between the variables. Aburbeian et al. (2022) reiterated that the correlation coefficients vary as follows: weak relation ($0.3 < r < 0.5$), moderate relation ($0.5 < r < 0.7$), and strong relation ($0.5 < r < 0.7$). Content analysis analyzes the online students' perceived advantages and disadvantages of collaborative learning tools by identifying units of meaning, labeling them with codes, grouping similar instances under a category, and describing the categories into one theme. The researcher utilized Microsoft Excel for descriptive statistics

analysis, IBM SPSS Statistics software for reliability and correlation analysis, and QDA Miner for qualitative content analysis.

RESULTS AND DISCUSSION

This section presented the results and discussions of the data gathered. This section also provided an interpretation of the data concerning the research objectives.

Socio-demographic Characteristics of the Respondents

Among the 67 students, 61 (91.04%) were aged 18 to 24. Four (4 or 5.97%) were 25 to 34. Two (2 or 2.99%) were 35 to 44. None of the respondents were 45-54, 55-64, or 65 and above. Also, it showed that 49 out of 67 (73.13%) are female, comprising most respondents, while 14 (20.90%) are male and come second. Three (3 or 4.48%) prefer not to say their gender. Moreover, one (1 or 1.49%) indicated others and specified it as bisexual. Assessing the educational profile of the respondents, many students (31.34%) were from the fourth-year level, 28.36% from the first year, 20.90% from the second year, 16.42% from the third-year level, and 2.99% were from the fifth-year level. It also showed that most students (89.55%) are full-time students. In addition, more than half of the students (64.18%) are from BAMS, 26.87% from BES, 5.97% from AA, and 2.99% from AADDA.

Reliability and Internal Consistency of the Questionnaire

Table 1 showed the reliability analysis measures items' reliability and internal consistency within a group of questions using IBM SPSS Statistics 26. The Cronbach's alpha (α) of the overall instrument is 0.901. All the resulting values are within the acceptable range of 0.70 to 0.95 (Tavakol & Dennick, 2011). Hence, it indicates the research instrument's reliability.

Table 1 – Cronbach's alpha of each Variables and Overall Questionnaire

Variable	N of Items	Range	Cronbach's alpha (α)
Perceived Ease of Use (PEOU)	4	1-4	0.861
Perceived Usefulness (PU)	4	5-8	0.914
Attitude Towards Usage (AT)	3	9-11	0.886
Behavioral Intention (BI)	4	12-15	0.909
Actual Usage (AU)	3	16-18	0.935
Total	18	18	0.901

Online Students' Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI), and Actual Usage (AU) of Collaborative Learning Tools

This study utilized descriptive analysis to determine the online students' Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI), and toward Actual Usage (AU) of collaborative learning tools. The questionnaire used a seven-point Likert Scale (Strongly Disagree = 1 to Strongly Agree = 7 to determine the PEOU, U, AT, and BI and (Never = 1 to Always = 7) to determine AU.

Data in Table 2 showed that online learners somewhat agree with all the statements under Perceived Ease of Use (PEOU), with a mean value ranging from 5.7015 to 5.8955. This

suggested that the respondents perceived using collaborative learning tools as easy to learn, clear, easy to use, and free from effort exertion.

On the other hand, online students' Perceived Usefulness (PU) resulted in somewhat agreement and agreement. Using collaborative learning tools to enhance academic performance and productivity resulted in 5.8806 and 5.9952 mean values, which reflected some agreement. While, accomplishing tasks more quickly and useful in one's education resulted in an agreement with 6.0299 and 6.4776 mean values. Still, the respondents perceived using collaborative learning tools as useful.

Moreover, Attitude Toward Usage (AT) showed some agreement with the statements. The statement about liking the usage of collaborative learning tools resulted in some agreement with a mean of 5.8358. The rest of the statements about collaborative learning tools as worthwhile, very desirable, and favorable to use resulted in an agreement with a mean of 6.0746 to 6.3134. Although these results suggested varied agreement, online students still have a positive attitude towards integrating collaborative learning tools in their education.

Furthermore, online students' Behavioral Intention (BI) revealed agreement and some agreement with the statements. Online students agreed with the statements regarding assistance to academic activities and usage in the future, resulting in 6.0149 and 6.1343 mean. The statement about using collaborative learning tools as often as possible, with a 5.6269 mean, showed some agreement. The results still exhibited the likelihood of using collaborative learning tools, but they varied at the discretion of online students.

Lastly, Actual Usage (AU) of Collaboration Tools revealed that online students use collaborative learning tools frequently and usually with the mean values from 4.9701 to 5.4925. Online students might use collaborative learning tools less per week. Still, results suggested often usage of online students the collaborative learning tools collectively, as reflected in the overall and monthly usage statements.

Table 2 – Descriptive Analysis of the Students' Acceptance on the Use of Collaborative Learning Tools

Code	Statement	Mean
PEOU1	Learning to use collaborative learning tools would be easy for me.	5.8358
PEOU2	My interaction with collaborative learning tools is clear and understandable.	5.8955
PEOU3	It would be easy for me to find information on collaborative learning tools.	5.7015
PEOU4	I find collaborative learning tools easy to use.	5.8507
PU1	Using collaborative learning tools would enable me to accomplish tasks more quickly.	6.0299
PU2	Using collaborative learning tools would improve my academic performance.	5.9552
PU3	Using collaborative learning tools would increase my productivity.	5.8806
PU4	I find collaborative learning tools useful in my education.	6.4776
AT1	I think it is worthwhile to use collaborative learning tools.	6.3134
AT2	I like using collaborative learning tools.	5.8358
AT3	I think it is very desirable to use collaborative learning tools for academic related	6.2239
AT4	purposes.	6.0746
	I have a generally favorable attitude toward using collaborative learning tools.	
BI1	I intend to use collaborative learning tools to assist my academic activities.	6.0149
BI2	I intend to use collaborative learning tools as often as possible.	5.6269
BI3	I intend to use collaborative learning tools in the future.	6.1343
AU1	On average, how frequently do you use online collaborative learning tools?	5.4925
AU2	On average, how much time do you spend per week using online collaborative learning tools?	4.9701
AU3	On average, how much time do you spend per month using online collaborative learning tools?	5.4030

Relationship between online students' Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Towards Usage (AT), Behavioral Intention (BI), and Actual Usage (AU) of Collaborative Learning Tools

The correlation of Perceived Ease of Use (PEOU) to Perceived Usefulness (PU) resulted in r = 0.671. It denotes a moderate positive correlation, suggesting that online students who find collaborative learning tools easier to use also tend to find them more useful. The online students' Perceived Ease of Use (PEOU) towards Attitude Towards Usage (AT), Perceived Usefulness (PU) towards Attitude Toward Usage (AT), and Attitude Toward Usage (AT) towards Behavioral Intention (BI) resulted to 0.790, 0.823, and 0.794 respectively. These showed positive sign with a strong association. This suggests that online students who find collaborative learning tools easier to use and useful also tend to have a more favorable attitude toward using them. Also, online students who find who find collaborative learning tools more useful tend to have a more favorable attitude toward using them. The coefficient value of Behavioral Intention (BI) towards the Actual Usage (AU) is 0.593 with a positive sign indicating a moderate association. It means that stronger intention of using collaborative learning tools from online students are more likely to actually use them. All resulted to a p-value less than 0.01 making the correlation indeed significant.

To summarize, Table 3 presents the correlation coefficients (r) among the variables using IBM SPSS Statistics 26.

Table 3 – Correlation Among Variables

	Perceived Ease of Use (PEOU)	**Perceived Usefulness (PU)**	**Attitude Towards Usage (AT)**	**Behavioral Intention (BI)**	**Actual Usage (AU)**
Perceived Ease of Use (PEOU)	1				
Perceived Usefulness (PU)	.671**	1			
Attitude Towards Usage (AT)	.790**	.823**	1		
Behavioral Intention (BI)	.612**	.735**	.794**	1	
Actual Usage (AU)	.338**	.441**	.481**	.593**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Actual Usage of Collaborative Learning Tools Among Online Students

Respondents were asked to rank the tools based on their usage to determine the actual usage of collaborative learning tools (1 = highest to 6 = lowest). Based on the results in Table 4, most respondents ranked communication significantly higher than the rest, with a mean value of 2.6148, the only type with a value less than 3. On the other hand, online students placed resource management, ideation and co-creation, project management, and presentation and archiving in the middle ranking and almost identical with one another as the four types reached a mean value of more than 3, from 3.2836-3.8806. Conversely, consensus building was the only type with a mean value of more than four, with a 4.3284 mean, implying the lowest ranking from most respondents.

Table 4 – Descriptive Analysis of Types of Collaborative Learning Tools

Rank	Type of Collaborative Learning Tools	Mean
1	Communication	2.6418
2	Resource Management	3.2836
3	Ideation and Co-Creation	3.3731
4	Project Management	3.4925
5	Presentation and Archiving	3.8806
6	Consensus Building	4.3284

Furthermore, the respondents were also asked to identify the name of the application or website they mostly used for each type of collaborative learning tool. Some respondents answered one, more than one, and none from all the types indicated, making the total unequal to the number of respondents, which is 67.

As shown in Table 5, the majority of the responses (90.79%) mentioned Zoom, Google Meet, Discord, and Facebook as their most used collaborative learning tools for communication. Less than 10% of the responses included various applications such as Slack, Trello, Microsoft Teams, Miro (5.93%), and UPOU MyPortal (3.29%), as expected since it is the university's platform with a messaging feature.

Table 5 – Most Used Collaborative Learning Tools for Communication

Rank	Type of Collaborative Learning Tools	Percentage
1	Zoom	33.55%
2	Google Applications	25.66%
3	Discord	16.45%
4	Facebook Messenger	15.13%
5	Others	5.93%
6	UPOU MyPortal	3.29%
	Total	100.00%

Cumulatively, Google Products (80.72%) such as Google Drive, Docs, and Sheets dominated the online students' preference to use as a shared storage space in Table 6. Although Microsoft Office Suite (9.64%), OneDrive, and Excel, as enumerated, were second on the list, they still have a significant margin as compared with the usage of online students on resource management tools. The remaining less than ten percent included other Cloud-based Backup and other types of tools (9.63%) such as DropBox, TeraByte, iCloud, Pinterest, Myportal, and Notion.

Table 6 – Most Used Collaborative Learning Tools for Resource Management

Rank	Type of Collaborative Learning Tools	Percentage
1	Google Products	80.72%
2	Microsoft Office Suite	9.64%
3	Other Cloud-based Backup	6.02%
4	Others	3.61%
	Total	100.00%

As shown in Table 7, the online students' most preferred tool for ideation and co-creation is Canva (36.19%), which covers more than a third of the results. The second on the list was Google products (35.24%), such as Google Docs, JamBoard, Drive, Suite, Classroom, and Slides, which resulted in only a few percentages lower than Canva. Generally, the first two tools dominated the tools that online students use for ideation and co-creation tools. Some of the responses (11.43%) mentioned virtual bulletin boards like Miro, Excalidraw, FreeForm, MindMeister, Mural, Padlet, Zoom Whiteboard, and FigJam as their preferred tools for this type. A few responses (7.62%) mentioned product development tools like Figma and Jira to interact directly with members regarding their projects. A little less than ten percent (9.53%) of the responses identified tools they still used for ideation and co-creation despite a different primary purpose, such as notetaking applications (GoodNotes, Notion, and Obsidian), communication (Discord and Facebook Messenger), other (Microsoft Office Suite and Pinterest), and no specified tools used at all.

Table 7 – Most Used Collaborative Learning Tools for Ideation & Co-Creation

Rank	Type of Collaborative Learning Tools	Percentage
1	Canva	36.19%
2	Google Products	35.24%
3	Virtual Bulletin Boards	11.43%
4	Product Development Tools	7.62%
5	Others	6.67%
6	None	2.86%
	Total	100.00%

In Table 8, almost half of the responses identified Google products (47.12%), namely Google Calendar, Docs, Sheets, and Drive, as their most used tool for project management. Next is Notion (24.04%), which resulted in almost a quarter of the responses. Less than 20% of the specified tools under project management contained list-making applications (12.50%), including Asana, Trello, ClickUp, To-Do lists, and Notes and calendar/time schedulers (6.73%) such as personal calendars, shared calendars, When2Meet, Reminders, Pomodoro, Momentum extension, and Calendly. With this, the collective Google products, notetaking applications, and schedulers are the most used tools for project management, totaling 90.39%. This allotted less than 10% to other tools like communication (Discord, Facebook Messenger, Zoom, and UPOU MypPortal), Microsoft Office Suite (Microsoft Excel), and none, as few online students mentioned they use for project management.

Table 8 – Most Used Collaborative Learning Tools for Project Management

Rank	Type of Collaborative Learning Tools	Percentage
1	Google Products	47.12%
2	Notion	24.04%
3	List Making Applications	12.50%
4	Calendar/Time Schedulers	6.73%
5	Communication Tools	4.81%
6	Microsoft Office Suite	2.88%
7	None	1.92%
	Total	100.00%

In Table 9, The first on the list is slide presentation makers, which Canva (30.77%) dominates, followed by Microsoft PowerPoint and Pechakucha (5.13%). Slightly lower than the first were communication tools that covered more than one-third of the list (35.04%), including Zoom, Discord, Facebook Messenger, and Jitsi. Google applications (26.50%), including Google Meet, Slides, Drive, YouTube, and Classroom, resulted in more than a quarter of the responses to online students' preferred tools for presentation and archiving. Less than two percent of the responses identified unclassified tools (1.71%) with previously mentioned examples such as UPOU MyPortal and GitHub. Although some online students mentioned that they did not use presentation and archiving tools (0.85%), it was insignificant compared to almost all the responses (97.44%).

Table 9 – Most Used Collaborative Learning Tools for Presentation and Archiving

Rank	Type of Collaborative Learning Tools	Percentage
1	Slide Presentation Makers	35.90%
2	Communication Tools	35.04%
3	Google Applications	26.50%
4	Others	1.71%
5	None	0.85%
	Total	100.00%

More than half of the responses identified communication tools (50.56%) as a tool for consensus building, including Facebook Messenger, Discord, and Zoom, as seen in Table 10. Next are Google applications (25.84%) like Google Forms, Docs, Drive, and Sheets, which covered a little more than a quarter of the responses. Other applications mentioned by the online students include a variety of tools such as When2Meet, Notion, Canva, Rock, UPOU Tagpuan, Threads, and Twitter, which were 13.48% of all the responses. Consensus building has the highest percentage of responses among all the collaborative learning tool types, with none (6.74%) mentioned as their most used tool. This suggests that some online students rely on other tools or methods to reach a consensus. The lowest number of responses resulted from building applications (3.37%) like StrawPoll, tally.so, and UXtweak. Generally, most of the tools mentioned already had a polling feature, but such tools were not exclusive to consensus building, such as in communication, Google applications, etc.

Table 10 – Most Used Collaborative Learning Tools for Consensus Building

Rank	Type of Collaborative Learning Tools	Percentage
1	Communication Tools	50.56%
2	Google Applications	25.84%
3	Others	13.48%
4	None	6.74%
5	Form Building Applications	3.37%
	Total	100.00%

Perceived Advantages and Disadvantages of Collaborative Learning Tools Among Online Students

Results in Figure 3 showed that the perceived advantages of using collaborative tools among online learners were workflow, usability, and social. More than half of the respondents mentioned workflow (52.52%) as an advantage, which included efficiency, collaboration, communication, and productivity, which improved group management. Next was the usability (31.65%) advantage. It consumed more than a quarter of the advantages that online students identified as accessibility, real-time tracking, convenience, learning, skills development, time efficiency, and cost efficiency, which lessened the complexity of collaboration. Lastly, the responses comprised less than 20% of the advantages, which were social (15.83%), through engagement, connection, and community, which brought online students together, easing the distance.

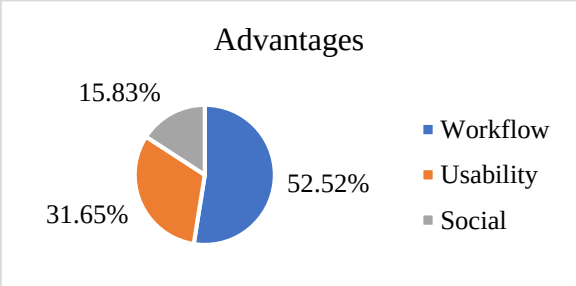


Figure 3 – Perceived Advantages of Using Collaborative Learning Tools

The perceived disadvantages of collaborative learning tools among online students were focus, usability, social, and none. As shown in Figure 4, more than a third of the responses mentioned the workflow (34.62%) as a disadvantage, which included the requirement of more attention, group coordination, physical interaction, personal challenges, and distractions. These exemplifications hindered online students' focus and ability to accomplish tasks using collaborative learning tools. The second and third categories had a little less than the third of

the responses were technical (30.77%) and usability (28.21%) disadvantages. Online students enumerated technical disadvantages such as internet dependency, technical error, and privacy and security issues. These technical concerns focused on issues for service providers. On the other hand, online students elaborated on usability disadvantages, which discussed the user-end problems such as more skill requirements, not being user-friendly, and availability and cost. Lastly, a portion of 6.41% of the responses mentioned that there were no known disadvantages of using collaborative learning tools in their education.

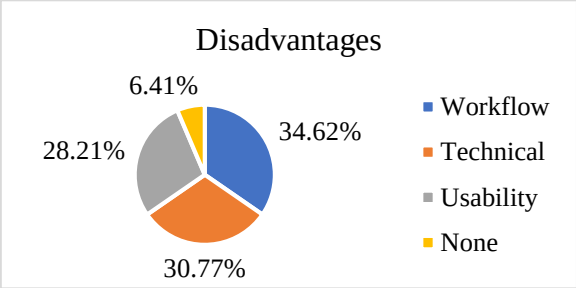


Figure 4 – Perceived Disadvantages of Using Collaborative Learning Tools

As evident from Figures 3 and 4, workflow and usability both reoccurred in the advantages and disadvantages of collaborative learning tools. This suggests that while some online students recognized the potential benefit of collaborative learning tools, others found them challenging.

CONCLUSION

Students in the 21st century require collaboration as one of the 4Cs learning skills that every learner should possess. Collaborative tools used in distance learning alleviate geographical restrictions for online students. This study aims to understand better online students' perceptions, relationships, actual usage, and perceived advantages and disadvantages of collaborative learning tools.

The Perceived Ease of Use (PEOU) of collaborative learning tools resulted in some agreement, which denoted that some online students find using these tools was free from effort. Most online students also recognized the benefit and positively recognized the collaborative learning tools in their education, as the Perceived Usefulness (PU) and the Attitude Towards Usage (AT) resulted in an agreement. Behavioral Intention (BI) still exhibited a likelihood of using collaborative learning tools in their education despite only resulting in some agreement.

Correlational results showed that online students' Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude Toward Using (AT), and Behavioral Intention to Use (BI) positively influence each component that predicts and confirms the Actual Usage (AU) of collaborative learning tools.

This study also investigated online students' actual usage of collaborative learning tools and their types. Respondents mentioned more than one tool, as the number of examples exceeded the respondents' number. It means that most students frequently use more than one tool. However, there is also a case in which a respondent mentioned none like in presentation and archiving type. The results showed that the most used collaborative learning tool is communication, with Zoom being the most used tool. Resource management is the second most used type, with Google products being the most prevalent tool mentioned. The third type is ideation and co-creation, with Canva as the preferred tool. The fourth most used type is project management, with Google products as the most frequently used again. The fifth is presentation

and archiving, with variations of slide presentation makers being the most used. The least used type is consensus building through a collective communication platform.

In addition, this study also examined the advantages and disadvantages of using collaborative learning tools. The online students' responses established workflow, usability, and social advantages. Moreover, workflow, technical, usability, and no disadvantages were established from the responses of online students. Overlapping themes like workflow and usability are evident by comparing the advantages and disadvantages. Enhanced collaboration was an advantage for workflow, while group coordination was a disadvantage. For usability, it was contrasting to see cost efficiency as an advantage and cost issues as a disadvantage. The occurrence of these themes as an advantage and disadvantage also confirmed that there are two sides to collaborative learning tools. It can be helpful or detrimental depending on how online students use it.

Overall, this study offers a broader scope of understanding to gauge the University of the Philippines Open University students' usage of collaborative learning tools. It also demonstrated the validity of the Technology Acceptance Model (TAM) in predicting and confirming users' adoption of new technologies compared with related studies. At the same time, it also delivered a new direction as it investigated existing tools or platforms and the advantages and disadvantages of using collaborative learning tools. Still, this study suggests expanding the sample size to diversify the responses, as most respondents came from BAMS. It is also recommended to assess further the specified tools, such as Google applications and Zoom being present in all types. Facebook Messenger, Discord, Notion, Canva, and Microsoft Office Suite were exemplified in three or more types of collaborative learning tools. Highlighting the presence of UPOU MyPortal in the three types is crucial, considering it is one of the university's primary learning platforms. This study recommends that multimedia practitioners investigate workflow and usability concerns before developing learning technologies to grasp the user experience (UX) and human-computer interaction (HCI) further, as not all students can keep using them to guarantee their improved usage.

REFERENCES

Aburbeian, A. M., Owda, A. Y., & Owda, M. (2022). A Technology Acceptance Model Survey of the Metaverse Prospects. *AI*, *3*(2), 285-302. https://doi.org/10.3390/ai3020018

Ayu, M. (2020). Online learning: Leading e-learning at higher education. *The Journal of English Literacy Education: The Teaching and Learning of English as a Foreign Language*, *7*(1), 47-54. https://doi.org/10.36706/jele.v7i1.11515

Baharin, A. T., Lateh, H., Nathan, S. S., & mohd Nawawi, H. (2015). Evaluating effectiveness of IDEWL using technology acceptance model. *Procedia-Social and Behavioral Sciences*, 171, 897-904. http://dx.doi.org/10.1016/j.sbspro.2015.01.207

Carnegie Mellon University. (2009). Collaboration tools. Eberly Center for Teaching Excellence & Educational Innovation. Retrieved from https://www.cmu.edu/teaching/technology/whitepapers/CollaborationTools_Jan09.pdf

Chaudhari, T., Linge, A. A., Kakde, B. B., & Singh, M. (2023). Empirical Evaluation of Technology Acceptance Model for Predicting Actual Usage of Mobile Payment Apps. https://doi.org/10.5281/zenodo.7951826

Cheung, R., & Vogel, D. (2013). Predicting user acceptance of collaborative technologies: An extension of the technology acceptance model for e-learning. *Computers & education*, *63*, 160-175. https://doi.org/10.1016/j.compedu.2012.12.003

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334

Davis, F. D. (1989). User acceptance of information systems: the technology acceptance model (TAM).

Gilbert, B. (2015). Online learning revealing the benefits and challenges. Education Masters, 303. https://fisherpub.sjf.edu/education_ETD_masters/303

Granić, A., & Marangunić, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology*, 50(5), 2572-2593. https://doi.org/10.1111/bjet.12864

Lowes, S. (2014). How Much" Group" Is There in Online Group Work?. *Journal of Asynchronous Learning Networks*, *18*(1), n1. https://doi.org/10.24059/olj.v18i1.373

McLeod, S. (2023). Zone of Proximal Development. Simply Psychology. https://www.simplypsychology.org/zone-of-proximal-development.html#ZPD-Theory

Moore, M. (2011). Vygotsky's Cognitive Development Theory. In: Goldstein, S., Naglieri, J.A. (eds) *Encyclopedia of Child Behavior and Development.* Springer, Boston, MA. https://doi.org/10.1007/978-0-387-79061-9_3054

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research*, *3*(1), 33-35. https://doi.org/10.21839/jaar.2018.v3iS1.165

Rhoads, M., Sierra, H., and Mercado Toro, J.T. (2018). Collaboration Tools. In M. Rhoads & B. Stachowiak (Eds.). Igniting Your Teaching with Educational Technology (p. 4). Innovate Learning, LLC. https://pressbooks.pub/edd7032017f2/chapter/4/

Robinson, H., Kilgore, W., & Warren, S. (2017). Care, communication, support: Core for designing meaningful online collaborative learning. *Online Learning Journal*, 21(4). https://www.learntechlib.org/p/183775/

Sawant, S. (2021). Online collaborative learning tools and types: Their key role in managing classrooms without walls. In Human-computer interaction and technology integration in modern society (pp. 12-41). IGI Global. http://dx.doi.org/10.4018/978-1-7998-5849-2.ch002

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). *American Journal of Distance Education*, 33(4), 289-306. https://doi.org/10.1080/08923647.2019.1663082

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education*, *2*, 53. https://doi.org/10.5116%2Fijme.4dfb.8dfd

Wardlow, L., & Harm, E. (2015). Using appropriate digital tools to overcome barriers to collaborative learning in classrooms. *Educational Technology*, 32-35. https://www.learntechlib.org/p/175007/

Wu, B., & Chen, X. (2017). Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model. Computers in human behavior, 67, 221-232. https://doi.org/10.1016/j.chb.2016.10.028

ANALYSING RISKS IN ONLINE AND DISTANCE LEARNING: AN ENTERPRISE RISK MANAGEMENT APPROACH FOR OPEN AND DISTANCE LEARNING INSTITUTIONS

Raziana Che Aziz[A], Ahmad Izanee Awang[B], Tajudin Md Ninggal[C]

ABSTRACT

The widespread adoption of Online Distance Learning (ODL) has presented a variety of risks to institutions like Open University Malaysia (OUM), which affect both the sustainability and quality of educational delivery. To address these challenges, OUM has developed a comprehensive risk profile model, identifying 19 key risks. This paper highlights four of the most critical risks, namely technology vulnerabilities, academic integrity concerns, regulatory compliance challenges, and student engagement issues. Through a case study of OUM, this research explores the application of Enterprise Risk Management (ERM) in managing these high-risk areas. Notably, there is a lack of extensive research on the application of ERM in ODL within Malaysia, making this study a significant step in closing that gap. Our findings underscore the need for enhanced cybersecurity protocols, more stringent academic integrity measures, proactive compliance strategies, and innovative methods to boost student engagement. By integrating ERM into strategic decision-making, this study provides valuable insights for educational leaders seeking to build institutional resilience and ensure the delivery of high-quality, sustainable ODL programmes.

Keywords: *Online Distance Learning, Enterprise Risk Management, Academic Integrity, Technology Risks, Educational Sustainability*

[A] *PhD, Faculty of Technology and Applied Sciences, Open University Malaysia, Selangor, Malaysia. Email: raziana@oum.edu.my Orcid: https://orcid.org/0000-0002-5126-7923*

[B] *Doctor of Education, President's Office, Open University Malaysia, Selangor, Malaysia. Email: izanee@oum.edu.my Orcid: https://orcid.org/0009-0006-0872-9017*

[C] *PhD, Vice President Academic and Research's Office, Open University Malaysia, Selangor, Malaysia. Email: tajudin@oum.edu.my*

ENHANCING MASTER PROJECT COMPLETION FOR PART-TIME SCIENCE AND TECHNOLOGY MASTER'S STUDENTS AT OPEN UNIVERSITY MALAYSIA: INTEGRATING TECHNOLOGY AND SUPPORT SYSTEMS

Suhaila Abdul Hamid[A], Mariatul Liza Meor Gheda[B], Fathin Fakhriah Abdul Aziz[C]

ABSTRACT

This paper explores how technology and support systems can improve master's project completion rates among part-time Science and Technology students at Open University Malaysia. The study focuses on the challenges part-time students face, such as managing work, family, and academic commitments, and how these obstacles hinder timely graduation. Using Malcolm Knowles' Andragogy Theory and the Unified Theory of Acceptance and Use of Technology (UTAUT) as frameworks, the study examines how technology-based support tools can help students overcome these challenges. A mixed-methods qualitative approach, combining surveys and interviews, was employed to gather insights from 23 recent graduates and two (2) educational experts. Results indicated that effective time management, enhanced collaboration, and access to digital resources significantly impact project completion. Self-management skills emerged as the most critical factor, followed by collaboration and technology support. Recommendations include stronger institutional support through flexible learning environments, access to digital tools, and fostering learner characteristics such as self-discipline and technological proficiency.

Keywords: *part-time learners, technology support, project completion, self-management, Open Distance Learning (ODL)*

INTRODUCTION

Graduating on time (GOT) is a key goal for every higher education student, yet for part-time learners, this path is filled with additional obstacles. Balancing work, family, and study responsibilities requires careful management and external support. Bok (2021) identified work commitments, family responsibilities, and the financial burden of education as significant challenges for adult learners, particularly those in distance education. Pursuing a coursework master's adds to these pressures, especially when it comes to completing the research project, which often causes apprehension (McCarthy, 2015). As a capstone for science and technology students, the master's project demands critical thinking and problem-solving skills, making it an essential, yet difficult, aspect of their academic journey. Ruchina et al. (2015) emphasised the role of research in integrating higher education into today's

[A] *PhD in Engineering Technology, Faculty of Technology and Applied Sciences, OUM, Selangor, Malaysia. Email: suhaila_abdulhamid@oum.edu.my*
[B] *PhD in Urban Planning and Design, Faculty of Technology and Applied Sciences, OUM, Selangor, Malaysia. Email: mariatul_liza@oum.edu.my*
[C] *MSc. in Information Technology, Faculty of Technology and Applied Sciences, Open University Malaysia, Selangor, Malaysia. Email: fathinfakhriah@oum.edu.my*

innovative society, although it requires substantial commitment, particularly for part-time students juggling other responsibilities. The difficulty of balancing work, family, and study commitments is well-documented. Ryu (2020), as cited in Damalie et al. (2023), noted that time, marriage, and financial concerns hinder adult learners, with 68% employed, 85% handling household tasks, and many also managing childcare. This struggle is further reinforced by Hoon et al. (2019), cited in Muthukrishnan et al. (2022), who found that postgraduate students face challenges in academic research and writing, despite being expected to be independent. Thus, the master's project often becomes the most difficult hurdle in achieving GOT. These findings highlight the importance of time management and technological support in helping adult learners stay on track.

Technology has transformed learning environments, offering tools that support self-directed learning, a critical element in adult education (Diep et al., 2019; Loeng, 2020). These resources are especially useful for part-time learners working on their master's projects, which require significant self-discipline. However, overcoming the barriers to completing these projects within two semesters remains a challenge. This study draws on Malcolm Knowles' Andragogy Theory (1984) and the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003) to explore the challenges faced by Science and Technology postgraduate students at Open University Malaysia (OUM). This study's objectives are to explore the challenges faced by OUM's Science and Technology postgraduate learners during their master's project journeys; identify the critical factors that support successful project completion; explore the impact of technological and institutional support in overcoming these challenges; and identify the learner characteristics essential for effectively leveraging technology to ensure timely project completion. A mixed-methods qualitative approach, incorporating surveys and interviews, was employed. This included surveys with 23 recent graduates who completed their master's projects, alongside open-ended interviews with two (2) educational and technology experts.

LITERATURE REVIEW

This review examines the challenges faced by part-time postgraduate students and strategies for supporting their success, focusing on master's project completion. It covers the challenges of part-time study, essential project skills, technology's role in learning support, institutional support, and self-directed learning in adult education. By synthesising research from diverse fields, this review aims to provide a comprehensive understanding of the part-time postgraduate experience and identify the role of technology and institutional support mechanisms that can enhance the timeliness and quality of project completion.

Part-time postgraduate students face various challenges that can impact their academic progress and overall experience. One significant challenge is balancing work, family, and academic commitments. This often leaves students feeling overwhelmed and, in some cases, contemplating quitting. For example, a study of Doctor of Nursing Practice (DNP) students revealed that 83% worked full-time and faced competing demands (Hlabse et al., 2016). Additionally, part-time learners may miss out on the benefits of peer support and social learning opportunities in blended learning environments, even if they do not feel a strong need for peer support (Youde, 2020). For international students, adapting to a new educational system adds another layer of difficulty, and while peer mentoring programs can help, the transition remains challenging (Menzies et al., 2015). Another common struggle is postgraduate research writing, particularly for non-native English speakers, who often find themselves isolated without structured support (Jeyaraj, 2018). These examples show the

broad range of challenges part-time postgraduate students face, highlighting the need for institutions to provide more comprehensive support by leveraging on the use of technology. Flexible scheduling, mentoring programs, structured writing support, and technology tools could all contribute to improving completion rates and enhancing the student experience.

Completing a master's project requires a mix of general and specialised skills. In medical education, time management and critical evaluation of medical information are essential for project success (Hart et al., 2022). A key barrier identified was the lack of protected time for research activities, reinforcing the importance of good time management (Hart et al., 2022). In other fields, like Corporate Social Responsibility (CSR), the need for skills such as strategic thinking and coordination can be extended to managing a master's project (Osagie et al., 2019). Leadership skills are also crucial, particularly interpersonal communication, teamwork, and problem-solving, as seen in leadership curricula for surgical residents (Friendly et al., 2021). For instance, the ability to manage group projects or collaborations during a master's program can be influenced by these skills. Confidence in technical skills and the ability to assess and prioritise development areas, as identified in a training needs assessment for nurses, also applies to students managing their own skill gaps (Renning et al., 2022). Additionally, research in Science, Technology, Engineering, and Mathematics (STEM) fields shows that students' ability to imagine and plan their futures can impact their motivation and approach to project completion (Holmegaard, 2021). In short, time management, strategic planning, leadership, technical skills, and future-focused thinking are all critical for successfully completing a master's project. In addition, Stephen (2019) noted that technology has the potential to accelerate the research process, particularly in the early stages, which can be time-intensive due to the need to identify and gather key sources, followed by the detailed work of reading and analysing them. This becomes even more demanding for topics with a large body of existing literature. Uncovering facts is still the cornerstone of research. Advances in information technology provide researchers with increasingly powerful tools for gathering, verifying, and analysing data to identify patterns. Today, researchers can explore everything from the subatomic scale to the vast expanses of the universe. Large datasets, accumulated over decades for various purposes, are now accessible online to researchers worldwide (National Research Council (US) Office of Special Projects, 2001). Indeed, technology-driven tools and equipment significantly impact student satisfaction (Kakada et al., 2019). While Artificial Intelligence (AI) is recognised as a valuable tool for speeding up tasks like information gathering and supporting impact and interdisciplinarity inresearch, relying solely on it risks reinforcing negative aspects of academic culture. AI should serve to complement, rather than replace, human creativity in research (Chubb et al., 2021). In essence, completing a master's project relies on effective time management, planning, leadership, and technical skills, as well as the ability to plan for the future. Technology, including AI, can help streamline research tasks like gathering and analysing data. However, these tools should enhance, not replace, human creativity and problem-solving. Combining technology with human skills is crucial for completing projects efficiently and successfully.

The combination of technology and human skills not only improves project completion but also plays a key role in tackling the unique challenges part-time learners face. The widespread use of technology today provides flexible and accessible learning environments that accommodate their needs. The shift to online learning during the COVID-19 pandemic demonstrated how effective technology-enhanced learning can be for part-time students. For example, students in the MSc Computing Foundations module at Queen's University Belfast responded positively to both synchronous and asynchronous content delivery, and their performance remained steady despite the shift to online formats

(Pishchukhina et al., 2024). Technology-assisted coaching systems have also been shown to improve engagement and awareness among learners and their caregivers, particularly benefiting those from lower education backgrounds. These systems enable personalised learning experiences, which can be especially helpful for part-time students juggling multiple responsibilities (Nazare et al., 2022). In adult basic education, digital learning solutions have improved basic skills like literacy and numeracy, although their impact depends on the specific product and setting (Murphy et al., 2023). Data from digital footprints can also offer valuable insights into factors like social connectedness that affect learning outcomes, helping design better digital interventions for out-of-school learners (Huntington et al., 2023). The rapid move to online teaching during the pandemic uncovered both challenges and opportunities, stressing the importance of being prepared and communicating effectively to reduce disruptions for part-time learners (Ahmed & Opoku, 2021). Overall, technology offers significant potential for supporting part-time students by providing flexible, personalised, and data-driven educational experiences.

Building on the potential of technology to support part-time students, higher educational institutions can further enhance support for master's project completion by using the Unified Theory of Acceptance and Use of Technology (UTAUT) model, which helps explain how students adopt and interact with technology. The model identifies key factors, including performance expectancy, effort expectancy, social influence, and facilitating conditions, that could help boost the adoption of technology-based support systems in education (Rahi et al., 2019). For example, research on internet banking has shown that integrating UTAUT with elements like website design and customer service can significantly influence user intention, suggesting similar strategies could be used to enhance student engagement and increase project completion rates (Rahi et al., 2019). The UTAUT model has also been applied in driver state monitoring systems, showing the importance of addressing user concerns such as privacy and perceived usefulness, which are relevant in educational settings where data security and perceived utility of technology influence its adoption (Smyth et al., 2021). In healthcare, UTAUT has helped characterise clinical decision support systems, highlighting that performance and effort expectations are key to adoption. These insights can be applied to educational technologies to ensure they meet both student and faculty needs (Liu et al., 2021). Additionally, research on student technology adoption emphasises the importance of social influence and basic technology skills, suggesting that peer support and training could be crucial in institutional support systems for master's projects (VanDerSchaaf et al., 2023). Collaborative governance models used in large-scale projects also demonstrate the value of structured, collaborative approaches that could be adapted to help master's students complete their projects (Aaltonen & Turkulainen, 2022). By drawing on these insights, institutions can build more effective support systems for helping students finish their master's projects.

Self-Directed Learning (SDL) is a core principle of andragogy, which emphasises the autonomy and self-motivation of adult learners. According to Malcolm Knowles (as cited in Brandt, 2020), SDL involves a five-step process where individuals take initiative in assessing their learning needs, setting goals, identifying resources, selecting strategies, and evaluating outcomes. This model aligns closely with the demands of research, where learners must independently navigate complex inquiries. The rise of online and hybrid learning environments, particularly accelerated by the COVID-19 pandemic, has made SDL even more essential, as it allows students to manage their learning with greater flexibility.For instance, among Omani nursing students, specific learning styles like solitary, competitive, imaginative, and perceptive are positively correlated with SDL, whereas an analytical style showed a negative correlation (Ballad et al., 2021). In cognitive development, learners are

viewed as "intuitive scientists" capable of integrating observations with prior knowledge, though scientific reasoning remains challenging (Lapidow & Walker, 2021). This capacity for self-direction is crucial in research, where individuals must independently identify knowledge gaps, seek resources, and develop strategies for problem-solving.SDL enables researchers to take ownership of their work while still benefiting from the guidance of mentors or advisors. As Garrison (cited in Loeng, 2020) explains, this dynamic fosters a balance between autonomy and external feedback, enhancing both the researcher's independence and learning outcomes. The importance of SDL is further reflected in medical education, where high-performing students exhibit self-directed behaviours such as goal-setting, planning, and using effective learning strategies—skills critical to academic success (Foong et al., 2021). In lifelong learning, SDL particularly benefits those with prior knowledge and high motivation, factors that contribute significantly to course completion in open online courses (Sarsa et al., 2022). Moreover, well-designed online environments that support guided inquiry-based learning can foster SDL by engaging students and improving learning approaches, as demonstrated in studies where individual differences in experience and knowledge influenced outcomes (Mamun et al., 2022). Overall, SDL, as a central concept of andragogy, is essential not only for navigating the research process but also for enhancing learning in both formal education and lifelong learning contexts.

This literature review has examined the challenges faced by part-time postgraduate students in completing their master's projects. Key findings underscore the importance of self-management, collaboration, and essential research skills, along with leveraging technology and institutional support frameworks. These factors are critical for enabling adult learners to complete their master's projects both on time and with high quality, particularly in the open and distance learning environment. The conceptual framework for this study, as illustrated in Figure 1, reflects these elements that mapped well with Knowles' Andragogy Theory and UTAUT. The insights gained from this review can help inform policies and practices that enhance the part-time postgraduate experience, improve completion rates, and address the unique needs of these students in their academic pursuits.

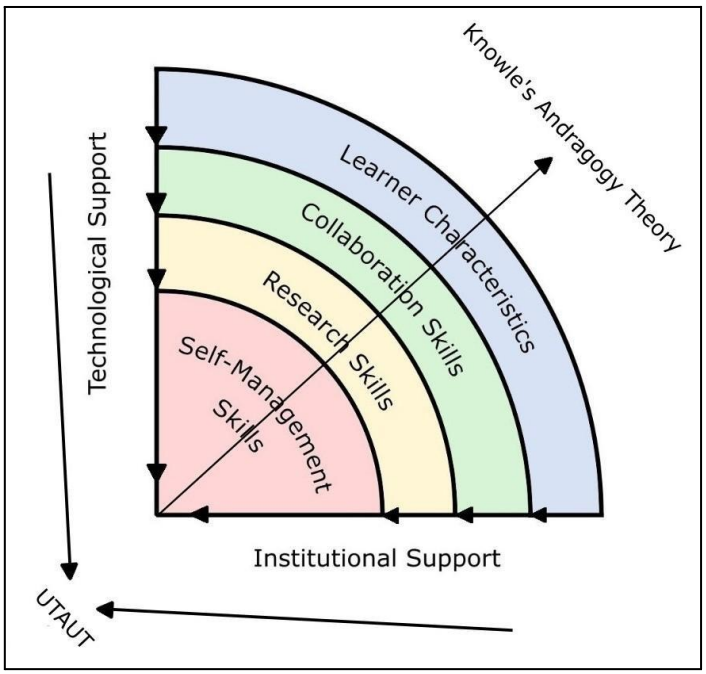


Figure 1 – Conceptual Framework

METHODOLOGY

This study applied a mixed-methods qualitative approach, incorporating surveys and interviews. The goal is to gain deeper insights into real-world issues, building on the work (Tenny, 2022). By incorporating both open-ended responses and Likert scales in the surveys, the study provided an initial understanding that serves as a foundation for more detailed analysis. Expert interviews add further depth, offering a comprehensive view of the challenges and opportunities. These interviews are chosen as the most suitable method for capturing individual expert perspectives and experiences. As Döringer (2021) noted, expert interviews are widely used in qualitative research to explore specialised areas of knowledge. The study examined students' experiences and the challenges they face in completing their master's project papers, while also drawing on expert insights into the role of technology and institutional support at Open University Malaysia (OUM). The findings aim to help OUM enhance the integration of technology and institutional support for part-time students, improving both the quality and timeliness of project completion and contributing to a higher on-time graduation rate (GOT).

The student survey data, collected using a 10-point Likert scale, was analysed quantitatively. As noted by Preston and Colman (2000), and cited in Hamed (2019), 10-point, 9-point, and 7-point scales are the most commonly preferred rating scales. This study uses the Intensity of Agreement 10-point Likert scale to measure the strength of students' agreement on key factors namely technology support, institutional support, research skills, collaboration skills, and self-management skills, all critical for completing their master's project papers. The scale allows students to express a range of agreement from complete disagreement to full agreement, offering a detailed perspective on the significance of these factors. Table 1 presents the definition of the 10 points likert scale based on Simms (2019).

Table 1 – Definition of 10 points Likert scale

Points	Definition
1	Very Strongly Disagree
2	Strongly Disagree
3	Disagree
4	Mostly Disagree
5	Slightly Disagree
6	Slightly Agree
7	Mostly Agree
8	Agree
9	Strongly Agree
10	Very Strongly Agree

Source: Simms et al. (2019)

While Table 2 presents the definitions of the Intensity of Agreement 10-point Likert scale used in this study, adapted from the Intensity of Importance 10-point Likert scale developed by Azman et al. (2013).

Table 2 – Intensity of agreement definition for this study

Intensity of agreement	Definition
0-2	Strongly Disagree
2-4	Disagree
4-6	Quite Disagree
6-8	Agree
8-10	Strongly Agree

Source: Adopted from Azman et al. (2013)

This scale provides a structured method for interpreting student responses, contributing to the overall analysis of how key factors affect project completion.

Thematic analysis is used to interpret the expert insights on how technology and institutional support assist part-time postgraduate students in enhancing research skills and managing time effectively to complete their master's project within two semesters. This method allows researchers to systematically identify, organise, and interpret key themes that reveal how these supports impact student success. Moreover, thematic analysis helps uncover learner characteristics essential for leveraging technology effectively to ensure timely project completion. As Braun and Clarke (2012) explain, this approach enables researchers to make sense of shared experiences and collective insights within the data. The analysis was conducted using feedback from two education and technology experts at OUM, each with 12 and 26 years of experience in Open and Distance Learning, offering a depth of understanding in this field.

RESULTS AND DISCUSSION

The survey involved 23 final year students from the Faculty of Technology and Applied Sciences who have just completed their master project paper. The demographic profile of the students participated in the survey as shown in Table 3.

Table 3 – Demographic profile of the students

Gender	Frequency	Percentage
Male	17	73.9
Female	6	26.1
Age		
30 - 34	4	17.4
35 - 39	9	39.1
40 - 44	5	21.7
45 - 49	3	13.0
50 - 54	2	8.7
Job Position		
Managerial & Leadership	8	34.8
Technical & Professional	15	65.2

This demographic data shows a group mainly consisting of males in technical and professional roles, with many in the 35-44 age range. Managerial and leadership positions include roles like General Manager, Senior Manager of HSE & Security, and Project Manager, while technical and professional roles cover positions such as Medical Doctor,

Consultant, and Technician.

Next, researchers gathered the response from the students on what are the challenges that they encountered in completing your master's project. The response is simplified as shown in Table 4.

Table 4 – Challenges faced during completion of the master project paper

Challenges Theme Context & Examples	Theme Category	Frequency	Percentage
Time management issues *"Time Management was my toughest hurdle - Construction Project Manager"*	Self-Management Skills	17	73.9
Limited access to resources "*limited knowledge of available technologies and resource access - Sr Asst Manager*"	Technology Support	2	8.7
Work and family commitment *"work and family commitment as when after MCO industry reboot need to secure the jobs first as prime target as the only breadwinner to support parents and family due to MCO aftermath - Regional Manager Malaysia"*	Institutional Support	2	8.7
Knowledge gaps *"limited knowledge in research- Medical Doctor"*	Research Skills	1	4.3
Formatting challenges *"formatting process was both time-consuming and frustrating - Unemployed"*	Institutional Support	1	4.3

Table 4 outlines the key challenges faced by part-time postgraduate students in completing their master's project paper, which aligns closely with the literature review findings. The most common challenge is time management, categorised under self-management skills, with a frequency of 17 (73.9%). This echoes Hart et al. (2022), who highlighted time management as crucial for project success, especially since students often lack dedicated time for research. Knowles' theory on self-directed learning, as cited by Brandt (2020), also supports the idea that students must balance autonomy and external feedback to manage their time effectively. Many students juggle work, family, and academic responsibilities, a finding consistent with research by Hlabse et al. (2016) and Foong et al. (2021), who linked strong time management and goal-setting skills to high performance. The second most common issue is limited access to resources, categorised under technology support (8.7%). The literature highlights how technology, including online learning tools and AI, can help address this problem. Stephen (2019) emphasised that technology can streamline the research process, particularly in data gathering and analysis. The UTAUT model (Rahi et al., 2019) explains how user-friendly technology and adequate support can make these tools more accessible to students. Work and family commitments, classified under institutional support (8.7%), are another significant obstacle, consistent with Hlabse et al. (2016), who found that full-time working postgraduate students often face conflicting demands. Research suggests institutions can assist by offering flexible learning schedules, mentoring, and structured writing support (Ahmed & Opoku, 2021; Youde, 2020). Knowledge gaps in research skills, mentioned in 4.3% of responses, highlight the need for foundational skills to complete academic projects. As Osagie et al. (2019) and Renning et al. (2022) observed, these gaps often involve technical and strategic thinking skills. Encouraging self-directed learning, as Lapidow & Walker (2021) noted, can help students address these gaps independently. Finally, formatting challenges, also noted in 4.3% of responses and categorised under institutional support, present a practical barrier that institutions could easily address by

providing pre-formatted templates or clearer guidelines, reducing student frustration. In summary, time management is the most significant challenge, followed by limited resource access and work-family balance, indicating the need for better self-management skills and stronger institutional and technological support. Institutions can assist by offering flexible learning options, technological tools, and structured support to help part-time students balance their commitments and succeed.

The student survey gathered data on the level of agreement regarding the factors influencing the completion of the master's project paper using 10 points likert scale, with the results presented in Table 5. The findings highlight the need for a holistic approach, integrating technology, institutional resources, research skills, collaboration, and strong personal management to ensure timely and successful completion of master's projects. Self-management skills are identified as the most critical, with a mean score of 8.78. Students recognize that effectively managing their time and balancing work, family, and academic commitments is essential. This aligns with Bok (2021), who pointed out that part-time students often face significant challenges in juggling these responsibilities, making time management a key factor in their success. Next, collaboration skills, with a mean of 8.70, are equally important. Support from peers, mentors, and advisors helps students refine their work and navigate challenges, as noted by McCarthy (2015). Collaboration is particularly important for part-time students, who may feel isolated in their studies. Technology support, with a mean of 8.48, also plays a vital role. Access to software, databases, and online tools allows students to organise and complete their research more efficiently. As Diep et al. (2019) highlighted, technology enhances self-directed learning and provides flexibility, both of which are crucial for part-time students managing multiple responsibilities. In addition, research skills, with a mean of 8.17, are essential for navigating the research process. While students understand the importance of finding, evaluating, and using academic sources, many still need structured support to further develop these skills, as noted by Hoon et al. (2019). Finally, institutional support, with a mean of 7.70, while still important, ranks slightly lower. Although students value access to libraries, advisors, and other resources, there is room for improvement. Universities could offer more flexible schedules, writing support, and tailored guidance to better meet the needs of part-time learners, as suggested by Hoon et al. (2019) and Ryu (2020). In conclusion, to help part-time students complete their master's projects and achieve GOT, universities should focus on strengthening self-management, enhancing collaboration, improving access to technology, and providing targeted research support. By addressing these areas, institutions can better assist students in overcoming the challenges of balancing multiple responsibilities and improving their chances of success.

Table 5 – Factors influencing project paper completion

Factors	Level of Agreement	Mean	Intensity of Agreement
Technology Support: *To what extent do you agree that the technology provided (software, databases, and online platforms) is essential for efficiently organising, analysing, and presenting work, leading to the on-time submission of the master's project?*	Very Strongly Agree (10): 9 Strongly Agree (9): 1 Agree (8): 9 Mostly Agree (7): 1 Slightly agree (6): 2 Slightly disagree (5): 1	8.48	Strongly Agree
Institutional Support: *To what extent do you agree that the university support, such as access to libraries, advisors, workshops, and other resources, is essential for the success of your master's project?*	Very Strongly Agree (10): 5 Agree (8): 8 Mostly Agree (7): 5 Slightly Agree (6): 3 Slightly Disagree (5): 2	7.70	Agree

Research Skills: *To what extent do you agree that the ability to find, evaluate, and use academic sources and research methods is essential for successfully completing your master's project?*	Very Strongly Agree (10): 7 Strongly Agree (9): 3 Agree (8): 5 Mostly Agree (7): 4 Slightly Agree (6): 3 Slightly Disagree (5): 1	8.17	Strongly Agree
Collaboration Skills: *To what extent do you agree that effectively engaging with peers, mentors, and advisors for feedback, idea-sharing, and project refinement is crucial for successfully completing your master's project?*	Very Strongly Agree (10): 11 Strongly Agree (9): 4 Agree (8): 3 Mostly Agree (7): 1 Slightly Agree (6): 3 Slightly Disagree (5): 1	8.70	Strongly Agree
Self-Management Skills: *To what extent do you agree that managing time, setting goals, and staying motivated to balance the project with other responsibilities are essential skills for completing your master's project?*	Very Strongly Agree (10): 14 Strongly Agree (9): 1 Agree (8): 3 Mostly Agree (7): 1 Slightly Agree (6): 2 Slightly Disagree (5): 2	8.78	Strongly Agree

Based on the final survey question, "*Overall, how would you describe your master project paper journey?*", it can be concluded that "*enhanced technology support, including reliable internet access and digital research tools, significantly improves part-time postgraduate students' ability to access resources, manage tasks, and complete their master's projects on time*". This conclusion aligns with the survey findings, where technology support was highly rated, and underscores its importance alongside self-management, collaboration, research skills, and institutional resources in addressing project-related challenges.

Building on the survey findings, two (2) experts from OUM, both experienced in supervising master's project papers and specialising in technology, were consulted to offer their insights on "*The impact of Technology on Supporting Part-Time Postgraduate Learners in Balancing Commitments and Enhancing Academic Success*"**.** The question posed to them was: *How do you think technology helps part-time postgraduate learners balance their personal, work, and academic commitments, improve research skills, and manage time to complete their master's project within two semesters?* Their responses shed light on the multi-faceted ways in which technology assists learners in achieving academic success, while efficiently managing their other life responsibilities. This study seeks to delve into these insights, uncovering the key roles of technological tools in enhancing flexibility, research capabilities, time management, and communication for part-time postgraduate students.

Enhancing Flexibility

Respondent A highlighted that *"technology assists part-time postgraduate learners by offering flexible learning platforms and mobile access, enabling them to study and engage with course materials at their convenience. This facilitates a balance between personal, work, and academic commitments."* Respondent B similarly pointed out the role of online platforms in providing flexible access to learning materials and sessions, allowing students to fit their studies around their busy schedules. This aligns with findings from previous studies, which suggest that effective tutoring and flexible learning environments can significantly enhance learning experiences for part-time adult learners (Youde, 2020).

Research Capabilities

Technology's contribution to research capabilities was also noted by both respondents. Respondent A focused on the efficiency gained through access to online resources and research tools, while Respondent B pointed to digital libraries and specialised tools as key factors in improving the quality of research. These insights mirror the conclusions of Chubb et al. (2022), who found that the use of AI and digital tools can expedite the research process and enhance the output's quality.

Time Management

Time management is another area where technology proves beneficial. Respondent A mentioned that project management tools, productivity apps, and virtual meeting platforms help students manage their academic tasks effectively. Respondent B agreed, adding that technologies such as cloud services and automated tools save time, helping students plan and organise their work more efficiently. This is consistent with findings by Kakada et al. (2019), who noted that technological support positively influences students' satisfaction by helping them manage their academic tasks more effectively.

Communication

Respondent A noted that virtual meeting platforms facilitate better planning, collaboration, and task execution, while Respondent B emphasised *"communication tools enable better interaction with peers and lecturers, fostering effective collaboration."*

Next, the experts also provide their views on "Technological Tools and Support for Enhancing Key Skills in Part-Time Learners". Respondent A suggested that access to databases like Scopus, training in research tools such as Mendeley and JASP, and AI writing tools like QuillBot can improve research and writing. They also recommend project management tools like Trello for time management and online workshops for skill-building. Respondent B highlighted enhancing the LMS with calendars, reminders, and better access to digital libraries, as well as AI tools for research and virtual study groups for collaboration on the importance of AI tools and virtual study groups for collaboration, aligning with prior findings that stress the importance of technological support in improving student satisfaction and engagement (Kakada et al., 2019; Venkatesh et al., 2003). Furthermore, Chubb et al. (2022) observed that AI tools accelerate the research process, helping learners to meet academic deadlines efficiently.

The final question seeks the experts' opinions on the "*Essential Learner Characteristics for Accelerating Master's Project Completion through Technology*"**.** While both responses highlight key characteristics, Respondent A provided a more concise yet comprehensive list by focusing on the interplay of technological proficiency, adaptability, and self-discipline aligns with research by Brandt (2020), who emphasises the importance of self-directed learning skills in mastering technological tools. The inclusion of critical thinking in Respondent B's response complements findings by Ballad et al. (2021), which demonstrate that critical thinking is necessary for making informed choices in an online learning environment, especially during the pandemic. Furthermore, Respondent B's mentioned of collaborative skills reflects the growing importance of teamwork facilitated by technology, as also supported by Youde (2020), who noted that effective tutoring and collaboration in blended learning environments can significantly improve academic outcomes for part-time learners. A combination of these characteristics, including

technological proficiency, critical thinking, and collaboration, provides a more holistic approach to mastering the use of technology for timely project completion.

CONCLUSION

The findings from this mixed-methods qualitative approach underscore the significant challenges part-time postgraduate students encounter in completing their master's project papers. Time management stands out as the most critical challenge, as students balance academic responsibilities with demanding work and family commitments. Additionally, limited access to resources and technology, alongside insufficient institutional support, further hindered their progress. These challenges highlight the need for institutions to provide more flexible learning environments, greater access to technological tools, and structured support systems to meet the needs of part-time learners. Experts consulted in the study emphasised the role of technology in improving time management, research capabilities, and overall flexibility for students. However, the ability to leverage these tools effectively depends on certain learner characteristics. Key traits such as self-discipline, adaptability, technological proficiency, and strong collaboration skills are essential for part-time learners to thrive. These characteristics enable students to navigate the challenges of project completion by efficiently using technological tools and balancing their commitments. In conclusion, institutions must focus on strengthening self-management skills, providing robust technological support, and fostering these essential learner characteristics to enhance students' success. Hence, "*Enhanced technological support, combined with flexible institutional frameworks and the development of essential learner characteristics such as self-discipline, adaptability, and technological proficiency, significantly increases the likelihood of timely completion of master's projects for part-time postgraduate students*". However, this study has limitations, including a small sample size and a focus on students from one faculty, limiting generalisability. It also only includes students who completed their projects, excluding those who may have dropped out. The use of self-reported data may introduce bias. Future research should include a larger and more diverse sample, track students throughout their studies, and explore the experiences of those who face greater challenges. It should also investigate the specific tools and supports that best help part-time learners succeed.

REFERENCES

Aaltonen, K., & Turkulainen, V. (2022). Institutionalization of a collaborative governance model to deliver large, inter-organizational projects. *International Journal of Operations & Production Management*, 42(8), 1294-1328. https://doi.org/10.1108/ijopm-11-2021-0741

Azman, M. N. A., Ahamad, M. S. S., A. Majid, T., Yahaya, A. S., & Hanafi, M. H. (2013). Statistical evaluation of pre-selection criteria for industrialized building system (IBS), *Journal of Civil Engineering and Management*, 19 (1), 131-140. http://dx.doi.org/10.3846/13923730.2013.801921

Ballad, C. A., Labrague, L. J., Cayaban, A. R. R., Turingan, O. M., & Balushi, S. M. A. (2021). Self‐directed learning readiness and learning styles among omani nursing students: implications for online learning during the covid‐19 pandemic. *Nursing Forum*, 57(1), 94-103. https://doi.org/10.1111/nuf.12664

Bok, G. I. (2021). Adult learners' challenges in distance learning: A case study in Universiti Sains Malaysia. *Issues in Educational Research*, 31(1), 19-36. http://www.iier.org.au/iier31/bok.pdf

Brandt, W. C. (2020). *Measuring student success skills: A review of the literature on self-direction*. Dover, NH: National Center for the Improvement of Educational Assessment.

Braun, V. & Clarke, V. (2012) Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds), *APA handbook of research methods in psychology, Vol. 2: Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 57-71). Washington, DC: American Psychological Association.

Chubb, J., Cowling, P. & Reed, D. (2022). Speeding up to keep up: exploring the use of AI in the research process. *AI & Society*, 37, 1439–1457. https://doi.org/10.1007/s00146-021-01259-0

Damalie, I. F., Agbanu, P., Fiadzomor, P., & Wilson, G. (2023). Knowing demographical challenges of adult learners: A vital tool for Administrators in managing adult learning programmes in the Public Technical Universities of Ghana. *Open Journal of Social Sciences*, 11, 441-454. https://doi.org/10.4236/jss.2023.114031

Diep, A. N., Zhu, C., Cocquyt, C., De Greef, M., Hien Vo, M., & Vanwing, T. (2019). Adult learners' needs in online and blended learning. *Australian Journal of Adult Learning*, 59 (2), 223-253. https://files.eric.ed.gov/fulltext/EJ1235812.pdf

Döringer, S. (2021). The problem-centred expert interview'. Combining qualitative interviewing approaches for investigating implicit expert knowledge. *International Journal of Social Research Methodology*, 24 (3), 265–278. https://doi.org/10.1080/13645579.2020.1766777

Foong, C. C., Ghouse, N. L. B., Lye, A. J., Holder, N. A. K. A., Pallath, V., Hong, W., … & Vadivelu, J. (2021). A qualitative study on self-regulated learning among high performing medical students. *BMC Medical Education*, 21(1). https://doi.org/10.1186/s12909-021-02712-w

Friendly, C., Villacreses, C., Mukherjee, R., Babilon, E., Caraway, J., Dieffenbaugher, S., Hink, A., Mellinger, J., Plumblee, L., Walters, M., & Talley, C. (2021). Leadership skills curriculum development for residents and fellows: a needs-assessment. *The American Journal of Surgery*, 222(6), 1079-1084. https://doi.org/10.1016/j.amjsurg.2021.10.007

Hamed, T. (2019). What is the best response scale for survey and questionnaire design; Review of different lengths of rating scale / attitude scale / likert scale. *International Journal of Academic Research in Management (IJARM)*, 8 (1), 1-12. ⟨hal-03741841⟩

Hart, J., Hakim, J., Rajneesh, K., Jeremy, R., Coorey, G., Kalman, E., Jenkin, R., & Bowen, D. (2022). Research supervisors' views of barriers and enablers for research projects undertaken by medical students; a mixed methods evaluation of a post-graduate medical degree research project program. *BMC Medical Education*, 22(1). https://doi.org/10.1186/s12909-022-03429-0

Hlabse, Mara Lea DNP, RN, CNP; Dowling, Donna A. PhD, RN; Lindell, Deborah DNP, RN, CNE, ANEF; Underwood, Patricia PhD, RN, FAAN; Barsman, Sarah Gutin MSN, RN, NNP-BC. (2016). Supports and barriers to successful progression in a DNP Program: Students' and graduates' perspectives. *Nurse Educator*, 41(5), 256-261. https://doi.org/10.1097/NNE.0000000000000251

Holmegaard, H. T. (2021). Master students' imagined futures. The interaction of students' resources, narrative repertoires and their thoughts about postgraduate futures within selected STEM Master Programmes. *Scandinavian Journal of Educational Research*, 65(7), 1217-1237. https://doi.org/10.1080/00313831.2020.1789213

Huntington, B., Pitchford, N., & Goulding, J. (2023). Education for out-of-school children: Unpacking driving factors of vulnerability via digital-learning footprint data in East Africa. *International Journal for Population Data Science*. https://doi.org/10.23889/ijpds.v8i3.2293

Jeyaraj, J. J. (2018). It's A Jungle Out There: Challenges In Postgraduate Research Writing. *GEMA Online Journal of Language Studies*, 18(1):22-37. https://doi.org/10.17576/GEMA-2018-1801-02

Kakada, P., Deshpande, Y., & Bisen, S. (2019). Technology support, social support, academic support, service support, and student satisfaction. *Journal of Information Technology Education: Research*, 18, 549-570. https://doi.org/10.28945/4461

Knowles, M. S. (1984). Andragogy in action: *Applying modern principles of adult learning*. San Francisco: Jossey-Bass Publishers.

Lapidow, E. and Walker, C. M. (2021). Rethinking the "gap": self-directed learning in cognitive development and scientific reasoning. *WIREs Cognitive Science*, 13(2). https://doi.org/10.1002/wcs.1580

Liu, S., Reese, T. J., Kawamoto, K., Del Fiol, G., & Weir, C. (2021). A systematic review of theoretical constructs in CDS literature. *BMC Medical Informatics and Decision Making*, 21(1), 102-102. https://doi.org/10.1186/S12911-021-01465-2

Loeng, S. (2020). Review article self-directed learning: A core concept in adult education. Education Research International, 2020, 1-12. https://doi.org/10.1155/2020/3816132

Mamun, M. A. A., Lawrie, G., & Wright, T. (2022). Exploration of learner-content interactions and learning approaches: the role of guided inquiry in the self-directed online environments. *Computers & Education*, 178, 104398. https://doi.org/10.1016/j.compedu.2021.104398

McCarthy, G. (2015). Motivating and enabling adult learners to develop research skills. *Australian Journal of Adult Learning*, 55 (2), 309-330. https://files.eric.ed.gov/fulltext/EJ1068383.pdf

Menzies, J., Baron, R., & Zutshi, A. (2015). Transitional experiences of international postgraduate students utilising a peer mentor programme. *Educational Research*, 57(4), 403-419. https://doi.org/10.1080/00131881.2015.1091202

Murphy, R., Wang, S., Bienkowski, M., & Bhanot, R. (2023). Digital learning solutions for improving adults' basic skills. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2023.2253860

Muthukrishnan, P., Sidhu, G. K., Hoon, T. S., Narayana, G. & Fook, C. Y. (2022). Key factors influencing graduation on time among postgraduate students: A PLS-SEM approach. *ASIAN Journal of University Education*, 18(1), 51-64. https://doi.org/10.24191/ajue.v18i1.17169

National Research Council (US) Office of Special Projects. Issues for Science and Engineering Researchers in the Digital Age. Washington (DC): National Academies Press (US); 2001. 2, *The Research Process in a Digital World*. Available from: https://www.ncbi.nlm.nih.gov/books/NBK208675/

Nazare, J., Woolf, A., Sysoev, I., Ballinger, S., Saveski, M., & Roy, D. (2022). Technology-assisted coaching can increase engagement with learning technology at home and caregivers' awareness of it. *Computers & Education*, 188, 104565. https://doi.org/10.1016/j.compedu.2022.104565

Osagie, E. R., Wesselink, R., Blok, V., & Mulder, M. (2019). Contextualizing Individual Competencies for Managing the Corporate Social Responsibility Adaptation Process The Apparent Influence of the Business Case Logic. *Business & Society*, 58(2). https://doi.org/10.1177/0007650316676270

Pishchukhina, O., Gordieieva, D., & Rainer, A. (2024). Delivering computing module for the large part-time software development class from pre- to post-pandemic: an online learning experience. *Journal of Systems and Software*, 210, 1-23. https://doi.org/10.1016/j.jss.2024.111959

Rahi, S., Mansour, M. M. O., Alghizzawi, M., & Alnaser, F. M. (2019). Integration of UTAUT model in internet banking adoption context: The mediating role of performance expectancy and effort expectancy. *Journal of Research in Interactive Marketing*, 13(3), 411-435. https://doi.org/10.1108/JRIM-02-2018-0032

Renning, K., van de Water, B., Brandstetter, S., Kasitomu, C., Gowero, N., Simbota, M., & Majamanda, M. (2022). Training needs assessment for practicing pediatric critical care nurses in Malawi to inform the development of a specialized master's education pathway: a cohort study. *BMC Nurs*, 21(6), 2-17. https://doi.org/10.1186/s12912-021-00772-3

Ruchina, A. V., Sentsov, A., & Kuimova, M. (2015). The Role of Research Work in the Training of Master Students Studying at Technical University. *Procedia - Social and Behavioral Sciences*, 215, 98-101. https://doi.org/10.1016/j.sbspro.2015.11.580

Sarsa, S., Hellas, A., & Leinonen, J. (2022). Who Continues in a Series of Lifelong Learning Courses?. *Proceedings of the 27th ACM Conference on Innovation and Technology in Computer Science Education*, 1, 47-53. https://doi.org/10.1145/3502718.3524752

Simms, L. J., Zelazny, K., Williams, T. F., & Bernstein, L. (2019). Does the number of response options matter? Psychometric perspectives using personality questionnaire data. *Psychological Assessment, 31*(4), 557-566. https://doi.org/10.1037/pas0000648

Smyth, J., Chen, H., Donzella, V., & Woodman, R. (2021). Public acceptance of driver state monitoring for automated vehicles: Applying the UTAUT framework. *Transportation Research Part F-traffic Psychology and Behaviour*, 83, 179-191. https://doi.org/10.1016/J.TRF.2021.10.003

Stephen, R. (2019). Using technology to speed up the research process. *In 26th Annual European Real Estate Society Conference (ERES: Conference)*, Cergy-Pontoise, France. https://eres.architexturez.net/doc/oai-eres-id-eres2019-353

Tenny S, Brannan JM, Brannan GD. Qualitative Study. [Updated 2022 Sep 18]. *In: StatPearls [Internet]*. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. https://www.ncbi.nlm.nih.gov/books/NBK470395/

VanDerSchaaf, H., Daim, T. U., & Başoğlu, N. (2023). Factors influencing student information technology adoption. *IEEE Transactions on Engineering Management*, 70(2), 631-643. https://doi.org/10.1109/tem.2021.3053966

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.

Vian, Ahmed., Alex, Opoku. (2021). Technology supported learning and pedagogy in times of crisis: the case of COVID-19 pandemic. *Education and Information Technologies*, 27, 365-405. https://doi.org/10.1007/S10639-021-10706-W

Youde, A. (2020). I don't need peer support: effective tutoring in blended learning environments for part-time, adult learners. *Higher Education Research & Development*, 39(5),1040-1054. https://doi.org/10.1080/07294360.2019.1704692

EXPLORING THE SENSE OF PRESENCE IN A VIRTUAL REALITY-ENHANCED CAMPUS TOUR OF AN OPEN UNIVERSITY

Anna Ma. Elizabeth Cañas-Llamas[A], Myra C. Almodiel[B], Marinela S. Hernandez[C], Anna Mhari C. Duria[D], Zyrene Edrei M. Villanueva[E]

ABSTRACT

The widening recognition of immersive technological innovations such as Virtual Reality (VR) to enhance learning experiences is now accentuated among e-learning advocates and practitioners. Online universities are increasingly adhering to the trend of using VR technology in campus tours, allowing them to expand their reach and engage a wider audience. The University of the Philippines Open University (UPOU) ventured on a learning innovation of developing the

UPOU Virtual Reality Campus Tour as it recognizes the potential the VR has to offer, in line with the university's contribution to SDG#4 (Ensure inclusive and equitable education and promote lifelong learning opportunities for all).
In order to realize the full potential of VR, it is important to explore how individuals experience virtual environments. Related studies have reported differences in the perception of presence through immersive technologies. This study aims to explore the sense of presence in a virtual reality-enhanced campus tour among participants in an online learning environment by measuring the levels of "Sense of being there," "Spatial Presence," "Involvement," and "Realness". Participants in this study used a head-mounted device while engaging with the UPOU Virtual Reality Campus Tour.

The results of this study hope to offer significant insights to enhance the understanding of potential gaps in presence experiences within an immersive virtual reality campus tour in an open university. Furthermore, the findings of this study also hope to contribute to the expanding body of knowledge in future research by exploring the long-term impacts of the virtual tour, investigating the experiences of diverse user groups, and incorporating objective measures to assess presence, especially in Asian contexts.

Keywords: *Virtual Reality, Virtual Campus Tour, Open University, Sense of Presence, Spatial Presence*

[A] *Bachelor of Science in Development Communication, College of Development Communication, University of the Philippines Los Baños, Philippines. Email: anna.canas@upou.edu.ph*
[B] *Doctor of Communication, University of the Philippines Open University, Philippines Email: myra.almodiel@upou.edu.ph Orchid: https://orcid.org/0000-0001-7062-7931*
[C] *Bachelor of Science in Mathematics and Science Teaching, Institute of Mathematics, College of Arts and Sciences, University of the Philippines Los Baños, Philippines. Email: mshernandez8@up.edu.ph*
[D] *Bachelor of Secondary Education Major in English, College of Teacher Education, Southern Luzon State University, Philippines. Email: annamhari.duria@upou.edu.ph*
[E] *Bachelor of Science in Development Communication, College of Development Communication, University of the Philippines Los Baños, Philippines. Email: zyreneedrei.villanueva@upou.edu.ph*

INTRODUCTION

The use of immersive technologies like Virtual Reality (VR) in education is becoming more popular among institutions delivering alternative modes of learning such as open and online universities. As online learning continues to evolve, so do the tools that faculty members use to engage and immerse students. VR, in particular, stands out as a powerful way to enhance learning and increase learner engagement by offering experiences that go beyond traditional methods. Its ability to simulate real-world environments and true-to-life experiences opens up new possibilities in various academic settings, such as virtual labs, interactive simulations, and most recently, virtual campus tours.

In the context of open and distance learning, VR technology has been increasingly applied in virtual campus tours to widen institutional reach and provide prospective students and stakeholders with a more immersive and realistic understanding of the learning environment. In addition, it allows better accessibility and availability of facilities and cost-effectiveness as students or visitors need not spend for physical tours. The University of the Philippines Open University (UPOU) has recognized the potential of VR to support its educational goals, particularly in contributing to Sustainable Development Goal 4 (SDG#4), which focuses on ensuring inclusive and equitable education and promoting lifelong learning opportunities. It also adds to the contribution of UPOU to the fourth Flagship Program of the University of the Philippines, which is open and distance e-learning (ODeL). UPOU has developed its own Virtual Reality Campus Tour to enhance its ability to connect with students and promote a deeper sense of institutional presence.

However, despite the growing use of VR in education, there is still a need to explore how effectively these virtual environments foster a sense of presence—an essential factor in immersive experiences. Presence, often described as the "sense of being there," is critical in ensuring users feel engaged and involved in the virtual space. Previous research has highlighted variations in how individuals perceive presence in virtual environments, suggesting that not all VR experiences offer the same level of immersion or user involvement (Freina & Ott, 2015; Biocca, 1997). Therefore, understanding the elements that contribute to a strong sense of presence is crucial for optimizing VR-enhanced educational tools.

Research Objectives

In general, this study hopes to explore the sense of presence in the use of the UPOU Virtual Reality Campus Tour in an open university. By examining these elements, this research aims to shed light on the effectiveness of VR in creating immersive campus experiences within an open university setting, offering valuable insights into potential gaps in presence experiences and contributing to the broader discourse on VR's role in elearning, particularly in Asian contexts. Specifically, this study aims to:

1. Assess the sense of being there experienced by users of the UPOU Virtual Reality Campus Tour.
2. Evaluate the spatial presence experienced by users of the UPOU Virtual Reality Campus Tour.
3. Measure the involvement experienced by users of the UPOU Virtual Reality Campus Tour.
4. Determine the realness experienced by users of the UPOU Virtual Reality Campus Tour.

Theoretical Framework

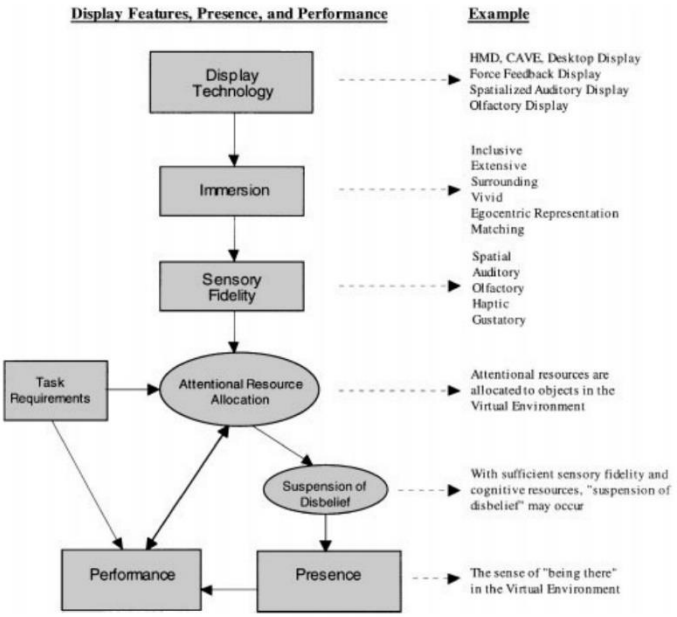


Figure 1 – Diagram of a model on immersion, presence, and performance.
(Source: https://vtechworks.lib.vt.edu/server/api/core/bitstreams/98833864-fb39-42bd-9b98-6e12cfcd096f/content)

Figure 1 shows a block diagram representing the current conceptualization of the relationship between immersion, presence, and performance. Presence in virtual environments has been defined as the degree to which participants feel that they are somewhere other than where they physically are when they experience the effects of a computer-generated simulation (Sheridan, 1992a, 1992b; Barfield & Weghorst, 1993; Slater & Usoh, 1994; Barfield, Sheridan, Zeltzer, & Slater, 1995). The goal of this study is to explore the sense of presence in the use of the UPOU Virtual Reality Campus Tour in an open university using this IPP (immersion, presence, and performance) model proposed by Bystrom et al. (1999). This model highlights the relationships between technological features, cognitive processes, and the sense of presence in a virtual environment. Applying this model to the VR-enhanced campus tour allows for a comprehensive examination of how various factors contribute to the overall effectiveness of the virtual experience.

LITERATURE REVIEW

As higher education is transforming, universities adapt to new student dynamics and technological progress. Part of this are evolving methods of campus tour through virtual reality. Some characteristics of virtual reality provide opportunities to increase student involvement, as a direct, interactive and immersive experience. Recent studies indicate that with the rapid advancement of technology, virtual tours have become a dynamic and engaging alternative to traditional campus visits. These digital experiences not only complement conventional methods of campus exploration but also significantly expand access to gain a comprehensive understanding of university life, facilities, and culture from the comfort of their own homes.

OPEN UNIVERSITY

The prime characteristic of open universities in their foundation stages was their capacity to innovate, and to do so fearlessly. Their place as a key institutional model for the future in countries at all stages of development will be the sustainability of that capacity to offer innovation.

An open university (OU) is an institution dedicated to adult education, with adapted curricula, free knowledge, and innovative methodology, whereas online or distance training is a training modality that does not require attendance and is adapted to the students' specific characteristics and needs (Inouye et al., 2018). Furthermore, distance education does not require face-to-face interaction; OUs may use distance education as part of the teaching methodology as well as it can be used as a training resource at the OU (Paul, 1993). The success of OUs goes back to the first comparative research with regular universities, whose results revealed that the need for both self- and externally regulated learning was similar in both types of higher education (Vermunt, 1998).

In addition, since their beginnings, these universities have been consolidating as one of the modalities par excellence among adults over 50 years of age (Klimczak & Kossakowska, 2018). Over recent decades, virtual campuses have become the main space for accessing learning content, and also as a meeting point for students and teachers (Caballe & Xhafa, 2013 in Hinojo et al. 2019). This system implemented by OUs has enabled their exponential growth, by facilitating ubiquitous access to information. Among the current new challenges for OUs are the constant updating and implementation of technologies that improve the learning process for students. For example, where emerging mobile technologies begin to be introduced, mobile learning approaches soon follow (Rangel & Pereira, 2016 in Hinojo et al. 2019).

Given that open universities have existed for half a century, and taking into account the huge changes they've brought to the access to and democratization of university learning, exploring the sense of presence in the use of the Virtual Reality Campus Tour in an open university is of scientific interest.

CAMPUS TOUR

Providing campus tours to potential students is an important responsibility for universities. These tours help new faculty and students grasp the university's expectations and community standards. Studies have found that campus tours are the single most decisive factor in a student's college choice (Doucette, 2019). As higher education institutions prepare for a steep enrollment decline that is expected to start in 2026, it is worth exploring strategies that can expand a university's recruitment base.

This starts with making quality tours accessible — for everyone. Universities worldwide are embracing virtual tours as a strategic tool to broaden their outreach and cater to diverse audiences. Virtual tours allow users to visualize and explore better about the campus environment, which can have a significant impact on them in making the final decision about which campus to choose in pursuing their studies (Suwarno & Murnaka, 2020).

VIRTUAL REALITY

Furthermore, Bakre et al (2017) as cited in Alenazi and Demir (2019) virtual reality tour is defined as a simulation of a real place that often includes multimedia such as images, text, sound effects, and video clips, a reproduction of actual location with the help of consecutive still images that can help in renewing a realistic presentation of reality. Rohizan et al. (2019) in an Enhanced Visitor Experience Through Campus Virtual Tour study stated that by implementing virtual tours, this enhances the visitor's experience towards campus exploration. This virtual tour helps in providing alternative ways for students and potential parents to easily walk around the campus without visiting the university's physical buildings.

Correspondingly, it was revealed that the use of virtual reality provides another alternative as a campus promotion media by providing an in-depth experience for users to quickly get around famous without having to visit the campus physical building of Bina Nusantara University in Indonesia (Suwarno & Munarka, 2020). Virtual reality transforms digital experiences into seemingly real environments where users can explore and interact with elements in ways that mimic or surpass reality. Virtual reality (VR), according to Kayabas (2005), is the reconstruction of reality. VR is a simulation that creates a realistic-looking environment using computer graphics. It is not a static environment; on the contrary, it responds to and interacts with the user's command inputs. Therefore, interaction is the key term in the definition of virtual reality. Immersion, interactivity, and imagination can be considered as three essential components of virtual reality (Burdea and Coiffet, 2003).

Virtual realities are generated through computers and a person can interact with this simulated environment. The person is immersed in this simulated environment where he/she can manipulate objects and perform many actions (UNESCO, 2018). Preliminary findings in a pilot project utilizing a VR photo-based tour as an alternative to International Christian University (ICU)’s traditional physical campus tours indicate that spatial presence in the virtual tour caused participants to feel more interested in the university and in actually visiting the campus (Figueroa, et al, 2020).

SENSE OF PRESENCE

Studies have shown that VR’s ability to immerse users significantly enhances the sense of "being there", which is compelling for learning outcomes in educational environments. The experience of presence implies a felt sense of ‘realness’—the being is really over there, within reach. In media and communication studies, where much of the work on perceptual presence has been done, presence is divided into three distinct subcategories: telepresence (spatial presence or environmental presence), self-presence, and social presence (Lee, 2004, as cited in Erickson-Davis, 2021).

The sense of presence is often measured through subjective reports, behavioral analysis, and sometimes physiological data. Key factors include interactivity, user control, and realism, all of which impact how participants experience presence in VR environments. As mentioned by Slater (2018), presence within the context of virtual reality is defined as one’s sense of being in the virtual world. The illusion is perceptual but not cognitive, as the perceptual system identifies the events and objects and the brain-body system automatically reacts to the changes in the environment, while the cognitive system slowly responds with a

conclusion that what the person experiences is an illusion.

Sense of presence in virtual reality refers to the perception of being physically present in a virtual environment, even though the user is actually in a different location. Pan et al. (2006) define it as it is the use of various graphic systems in order to create an immersive effect in three-dimensional interactive environments.

This study aims to explore the sense of presence in the use of the UPOU Virtual Reality Campus Tour in an open university to provide insights into how effectively the UPOU Virtual Reality Campus Tour delivers an immersive and engaging experience, highlighting areas for potential enhancement to better meet user expectations and improve overall satisfaction.

Scope and Limitation

The study was conducted at the University of the Philippines Open University in Los Baños, Laguna. The respondents were composed of 62 constituents from UP Open University – students, staff, and employees. The data were collected using an online questionnaire adapted from the Sense of Presence research instrument.

The limitation of this study includes the sample size which is bounded to the UPOU constituents, making the results not generalizable to the outside population. The study is also limited to the UPOU Virtual Reality Campus Tour while other virtual reality experiences may yield different results of sense of presence.

However, this study is expected to make a valuable contribution to our understanding of the sense of presence in an open university. Future research could expand upon this study by exploring the long-term impacts of the virtual tour, investigating the experiences of different user groups, and employing objective measures to assess presence.

DATA AND METHODOLOGY

The participants of this study are 62 UPOU constituents consisting of 31 male and 31 female participants. To attain the objectives of this research, a survey research method was conducted to gather the necessary data. The survey included the following: (1) the socio-demographic profile of the respondent; (2) a 7-point Likert scale to rate 14 statements that will assess the respondent's sense of presence based on the sense of being there, spatial presence, involvement, and experienced realism.

Data on the sense of being there, spatial presence, involvement, and experienced realism were calculated using frequency and percentage. Data were analyzed quantitatively for means. The scale used were as follows: Very Low (1.00 - 2.00): Indicates strong negative sentiment or lack of agreement; Low (2.01 - 3.00): Suggests mild disagreement or negative sentiment; Moderate (3.01 - 4.00): Reflects a neutral or balanced perspective; High (4.01 - 5.00): Indicates agreement or positive sentiment; Very High (5.01 - 6.00): Represents strong agreement or positive sentiment; Extremely High (6.01 - 7.00): Signifies very strong agreement or very positive sentiment.

RESULTS AND DISCUSSION

Socio-demographic profile of the respondents

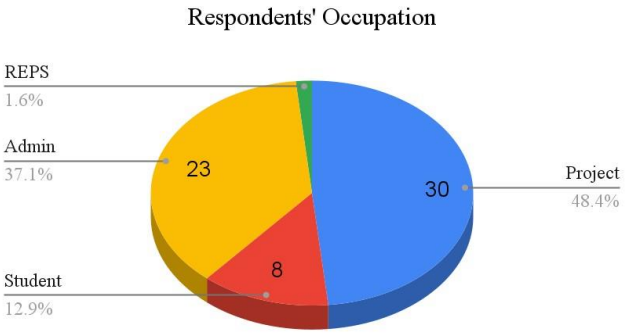


Figure 1 – Shows the occupation of the respondents who participated in the survey.

The study surveyed respondents consisting of UP Open University students, staff, admin, and REPS. 48.4% (30) of the respondents were composed of Project Staff/Research Assistants, 37.1% (23) of them were Admin, 12.9% were students, and the remaining 1.6% (1) is REPS.

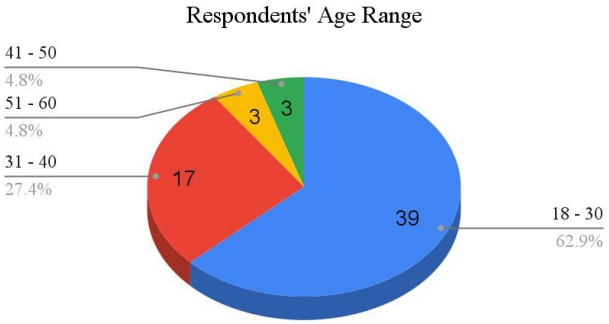


Figure 2 – Shows the age range of the respondents who participated in the survey.

The figure shows that 62.9% (39) of the respondents fall into the age bracket of 18 - 30, 27.4% (17) of them are between 31 - 40 years old, 4.8% (3) are between 41 - 50 years old, and 4.8% (3) are between 51 - 60 years old.

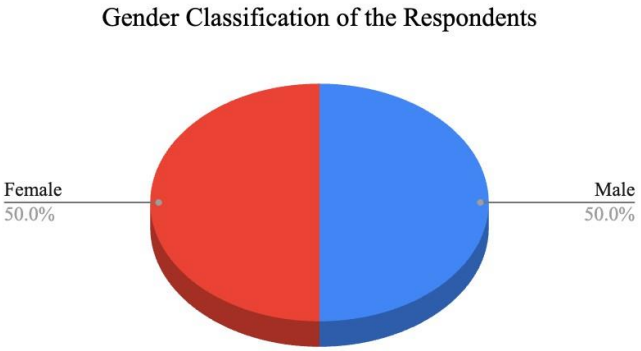


Figure 3 – Shows the gender classification of the respondents who participated in the survey.

Figure 3 shows that 50% (31) of the respondents are Male and 50% (31) of them are Female.

Sense of being there

The results in Table 1 show that the respondents have a very high level of agreement with the sense of being there in using the VR Campus Tour. Most of the respondents (85.7%) agreed when asked if, in the computer-generated world, they had a sense of "being there."

Spatial Presence

Table 1 –Sense of Being There

Code		Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	Mean	Level
Q1	In the computer-generated world I had a sense of "being there"	0	0	1.6%	11.1%	33.3%	22.2%	30.2%	5.69	Very High

The results in Table 2 show that the respondents have a high to very high level of agreement with the spatial presence in using the VR Campus Tour. Most of the respondents (93.7%) agreed that they felt the virtual world surrounded them. When asked if they felt like they were just perceiving pictures while using the VR Campus Tour, the majority of the respondents (54%) agreed. There was also a high agreement (65.1%) among the respondents if they did not feel present in the virtual space. Most of the respondents (61.9%) agreed that they had a sense of acting in a virtual space rather than something from outside. The majority of the respondents (84.1%) felt present in the virtual space.

Table 2 – Spatial Presence

Code		Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	Mean	Level
Q1	Somehow I felt that the virtual world surrounded me.	0%	0%	0%	4.8%	28.6%	30.2%	34.9%	5.97	Very High
Q2	I felt like I was just perceiving pictures.	0	0	1.6%	11.1%	33.3%	22.2%	30.2%	5.69	Very High
Q3	I did not feel present in the virtual space.	0	0	1.6%	11.1%	33.3%	22.2%	30.2%	5.69	Very High
Q4	I had a sense of acting in the virtual space, rather than operating something from outside.	0	0%	1.6%	11.1%	33.3%	22.2%	30.2%	5.69	Very High
Q5	I felt present in the virtual space.	0%	0%	1.6%	11.1%	33.3%	22.2%	30.2%	5.69	Very High

Involvement

The results shown in Table 3-4 indicate that most of the respondents have a high agreement with the involvement they felt when using the VR Campus Tour. The results in Table 3 show that 46% of the respondents are not aware of the real world surrounding them while navigating the VR. The results in Table 4 show that some of the respondents (42.8%) agree that they are not aware of the real environment; the majority of the respondents (61.8%) agreed that they still paid attention to their real environment, and most of the respondents (73.1%) agreed that they were completely captivated by the virtual world. There is a high to very high level of agreement for the statements related to the involvement of respondents in VR.

Table 3 – Involvement Q1

Code		Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	Mean	Level
Q1	How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)?	9.5%	7.9%	12.7%	22.2%	19.0%	23.8%	3.2%	4.19	High

Experienced Realism

Table 4 – Involvement Q2-Q4

Code		Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	Mean	Level
Q2	I was not aware of my real environment.	11.1%	6.3%	23.8%	14.3%	19.0%	19.0%	4.8%	4.02	High
Q3	I still paid attention to the real environment.	1.6%	6.3%	14.3%	14.3%	31.7%	19.0%	11.1%	4.73	High
Q4	I was completely captivated by the virtual world.	0%	1.6%	7.9%	15.9%	30.2%	30.2%	12.7%	5.19	High

The results shown in Table 5-7 indicate that most of the respondents moderately agreed on the experienced realism. Some of the respondents (46%) expressed that the virtual world seemed real to them. The majority of the respondents (82.6%) felt that their experience in the virtual environment seems consistent with their experience in the real world. Only a few of the respondents (19%) expressed that the virtual world seemed more realistic than the real world.

Table 5 – Experienced Realism Q1

Code		Completely Real (1)	2	3	4	5	6	Not real at all (7)	Mean	Level
Q1	How real did the virtual world seem to you?	9.5%	12.7%	23.8%	19.0%	19.0%	14.3%	0%	3.69	Moderate

Table 6 – Experienced Realism Q2

Code		Completely Real (1)	2	3	4	5	6	Not real at all (7)	Mean	Level
Q2	How much did your experience in the virtual environment seem consistent with your real world experience?	1.6%	1.6%	0.0%	12.7%	41.3%	36.5%	4.8%	5.23	Very High

Table 7 – Experienced Realism Q3

Code		Completely Real (1)	2	3	4	5	6	Not real at all (7)	Mean	Level
Q3	The virtual world seemed more realistic than the real world.	7.9%	15.9%	19.0%	36.5%	12.7%	6.3%	0%	3.50	Moderate

The findings from this study reveal that the VR Campus Tour has created a strong sense of "being there" and spatial awareness among the participants. There is a high agreement for the statements related to these elements which suggest that the respondents felt immersed in the virtual environment.

The results also show a high level of involvement among the participants as many of them reported being fully immersed in the virtual world and some reported that they were unaware of the real-world surroundings while navigating the VR. Despite this, there are still a significant number of participants that still paid attention to their real environment.

Despite the moderate level of agreement with the experienced realism among the participants, there is still a significant number that felt their virtual environment was parallel with their real-world experiences. There is still a relatively low percentage of participants who felt that the virtual world was more realistic than the real world, indicating that there is still room for improvement in terms of achieving a truly immersive and realistic experience.

CONCLUSION

The VR Campus Tour is a transformative innovation. It demonstrates a significant potential as a valuable tool for providing immersive virtual experiences. The study shows that there are high levels of sense of being there, spatial presence, involvement, and experienced realism among participants. This study also shows that the VR Campus Tour has high levels of involvement which indicates its effectiveness in immersing users into the virtual space, making them feel physically present in it. While the study shows that the VR Campus Tour reached a level of experienced realism, there is still a lot to improve on to make it more realistic. Innovating the VR campus tour by refining image quality, adding haptic feedback, incorporating more interactive elements, etc. Overall, the VR Campus Tour demonstrates its potential as a tool that can complement traditional campus tours. By improving and innovating identified areas, these virtual experiences can be more effective generally in promoting the university, attracting prospective students, showcasing campus life, and fostering a connection to the university.

RECOMMENDATION

Future research can focus on the long-term impacts of VR Campus Tours on student decision-making in terms of potential enrollment to the university. They can also investigate the experiences of diverse user groups and implementing objective measures of presence can provide more reliable results. Furthermore, exploring emerging technologies and integrating social interaction features might be considered to enhance the realism and immersion of VR Campus Tours. By addressing these recommendations, future research can contribute to the widespread adoption and effectiveness of VR campus tours in higher education.

REFERENCES

Alenazi, M., & Demir, F. (2019). Understanding virtual reality tours: a user experience study with the princess Norah University. International Journal of Current Research in Life Sciences, 8(10), 3248-3253.

Akgun, M. & Atici, B. (2022). The Effects of Immersive Virtual Reality Environments on Students' Academic Achievement: A Meta-analytical and Meta-thematic Study. https://files.eric.ed.gov/fulltext/EJ1325008.pdf

Biocca, F. (1997). The Cyborg's Dilemma: Progressive Embodiment in Virtual Environments. *Journal of Computer-Mediated Communication*, *3*(2). https://doi.org/10.1111/j.1083-6101.1997.tb00070.x

Bystrom, KE; Barfield, W; Hendrix, C. (1999). "A conceptual model of the sense of presence in virtual environments," Presence: Teleoperators and Virtual Environments 1999, Vol. 8 No. 2, 241-244. https://doi.org/10.1162/105474699566107

Doucette, D. (2021, March 30). Ensuring quality virtual campus tours for everyone. *EdTech Magazine*. https://edtechmagazine.com/higher/article/2021/03/ensuring-quality-virtual-campus-tours-everyone

Erikson-Davis, C., Luhrmann, T. M., Kurina, L. M., Weisman, K., Cornman, N., Corwin, A., & Bailenson, J. (2021). The sense of presence: lessons from virtual reality. Religion, Brain & Behavior, 11(3), 335–351. https://doi.org/10.1080/2153599X.2021.1953573

Figueroa, R. B., Mendoza, G. A. G., Fajardo, J. C. C., Tan, S. E., Yassin, E., & Thian, T. H. (2020). Virtualizing a university campus tour: a pilot study on its usability and user experience, and perception. International Journal in Information Technology in Governance, Education and Business, 2(1), 1-8.

Fowler, C. (2014). Virtual reality and learning: Where is the pedagogy? British Journal of Educational Technology, 46(2), 412–422. https://doi.org/10.1111/bjet.12135

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. *eLearning and Software for Education (eLSE)*, *1*(133), 10-1007.

Hinojo-Lucena, F.-J., Aznar-Díaz, I., Cáceres-Reche, M.-P. & Romero-Rodríguez, J.-M. (2019). A Tour of Open Universities Through Literature: A Bibliometric Analysis. International Review of Research in Open and Distributed Learning, 20(4), 116–131. https://doi.org/10.19173/irrodl.v20i3.4079

Holly, M., Pirker, J., Resch, S., Brettschuh, S., & Gütl, C. (2021). Designing VR Experiences – Expectations for Teaching and Learning in VR. Educational Technology & Society, 24(2), 107–119. https://www.jstor.org/stable/27004935

Inouye, K., Souza, F., Lost, S. C., & Silva, E. (2018). Impact of the third age open university on the quality of life of the elderly. Educação e Pesquisa, 44, 1–18. http://dx.doi.org/10.1590/S167846342017081429 31

Kayabaşı, Y. (2002). Sanal Gerçeklik ve Eğitim Amaçlı Kullanılması [Use for Virtual Reality and Educational Purposes]. Turkish Online, 151.

Klimczak, A., & Kossakowska, S. (2018). Language learning over 50 at the Open University in Poland: An exploratory study of needs and emotions. Educational Gerontology, 44(4), 255–264. https://doi.org/10.1080/03601277.2018.1454389

Pan, Z., Cheok, A. D., Yang, H., Zhu, J., & Shi, J. (2006). Virtual reality and mixed reality for virtual learning environments. Computers & graphics, 30(1), 20-28.

Paul, R. (1993). Open universities—The test of all models. In K. Harry, M. John, & D. Keegan (Eds.), Distance education: New perspectives (pp. 114–125). London, UK: Routledge.

Rohizan, R. B., Vistro, D. M., & Puasa, M. R. B. (2019, May). Enhanced visitor experience through campus virtual tour. In Journal of Physics: Conference Series (Vol. 1228, No. 1, p. 012067). IOP Publishing.

Vermunt, J. (1998). The regulation of constructive learning processes. British Journal of Educational Psychology, 68, 149–171. https://doi.org/10.1111/j.2044-8279.1998.tb01281.x

Suwarno, N. P. M., & Murnaka, N. (2020). Virtual Campus Tour (Student Perception of University Virtual Environment). J. Crit. Rev, 7, 4964-4969.

AI AND OER IN CHINA: TRANSFORMING THE FUTURE OF OPEN EDUCATION

Wen Tang [A], Xiangyang Zhang [B]

ABSTRACT

This study examines the evolving landscape of open educational resources (OER) in China in light of the transformative impact of artificial intelligence (AI), particularly generative AI tools such as ChatGPT-4o, on open education. It aims to examine the last 20 years of OER research and application in China through a systematic review while projecting future trends in the AI-driven era. Methodologically, the study utilises a comprehensive literature review to analyse policy documents, academic publications and institutional reports related to OER in China. The results suggest increasing integration of OER into Chinese higher education, supported by government policies and the active participation of universities and research institutions. Quantitatively, the number of OER initiatives has increased significantly, demonstrating a vibrant ecosystem that promotes innovation and accessibility. Furthermore, the study highlights the potential of AI tools to revolutionise the creation and distribution of OER and make educational resources more adaptable and personalised. The conclusion assumes that the AI-enhanced scenario presents both challenges and opportunities and requires strategic adjustments within the educational framework to harness the potential of AI for the further development of OER. This research provides a crucial Chinese perspective on the global OER movement, providing insights into future directions and promoting informed decision-making among open higher education stakeholders. Ultimately, this suggests that the use of AI can significantly enrich OER and enable a more inclusive, dynamic and sustainable educational environment.

Keywords: *artificial intelligence (AI), generative artificial intelligence (Gen AI), open educational resources (OER), AI-enhanced educational resources, sustainability*

INTRODUCTION

The landscape of education is undergoing a profound transformation, driven by technological advancements and changing societal needs (Zawacki-Richter et al., 2019). At the forefront of this evolution are Open Educational Resources (OER), Artificial Intelligence (AI) has emerged as a powerful catalyst, reshaping various aspects of education, including the development and dissemination of OER (Tuomi, 2018), which have emerged as a powerful tool for democratizing access to knowledge and promoting inclusive education. Over the past two decades, China has made significant strides in integrating OER into its higher education system. The advent of AI, particularly generative AI tools, has further accelerated this transformation, offering new possibilities for creating, distributing, and personalizing educational content

[A] *School of Open Learning, Jiangsu Open University, Jiangsu, China. Email: wentangnj@foxmail.com*
[B] *School of Open Learning, Jiangsu Open University, Jiangsu, China. Email: njxiangyangzhang@163.com*
Orcid: https://orcid.org/0000-0001-5245-7617

(Mishra et al., 2022). In China, the world's most populous country with a rich educational tradition, the adoption and development of OER have been particularly significant over the past two decades.

This study aims to examine the trajectory of OER in China over the last two decades of research and application, with a particular focus on the transformative impact of Artificial Intelligence, providing insights into how generative AI can enhance OER, thereby contributing to more personalized and adaptable educational experiences. As we stand on the cusp of an AI-driven era in education, understanding the interplay between OER and AI becomes crucial for shaping future educational policies and practices.

The objectives of this research are threefold:

1. To provide a comprehensive review of OER development and implementation in China from 2003 to 2023.
2. To analyze the current state of AI integration in OER within the Chinese educational context.
3. To project future trends and potential impacts of AI-enhanced OER in China's education system.

By addressing these objectives, this study seeks to contribute to the global discourse on OER and AI in education, offering valuable insights from the Chinese perspective. The findings of this research will be instrumental for policymakers, educators, and researchers in navigating the evolving landscape of open education in the age of AI.

LITERATURE REVIEW

The Global OER Movement

Open Educational Resources was first coined at UNESCO's 2002 Forum on Open Courseware. Since then, OER has been defined as teaching, learning, and research materials residing in the public domain or released under an open license that permits no-cost access, use, adaptation, and redistribution by others (Atkins et al. 2007; UNESCO, 2019). OER have gained prominence as a means to democratize access to educational materials and facilitate collaborative learning (Wiley, 2014). In tandem, the advent of AI, particularly generative AI tools like ChatGPT-4o, has the potential to reshape the way educational content is created, delivered, and personalized (Zawacki-Richter et al., 2019).

Globally, the OER movement began with initiatives such as the Massachusetts Institute of Technology's (MIT) OpenCourseWare setting a precedent for open access to educational materials (MIT OpenCourseWare, 2001). The concept of OER encompasses a broad range of educational resources that are freely available for use, adaptation, and distribution, promoting both educational equity and collaborative learning (Hewlett 2005). These initiatives have demonstrated the potential of open resources to reduce educational costs, improve access to quality materials, and foster innovation in teaching and learning (Wiley et al., 2014).

OER Development in China

In China, the development of OER has been closely tied to the country's broader educational reforms and technological advancements, and the adoption and proliferation of OER have been closely tied to national policies aimed at improving educational access and quality (Tlili et al. 2019). The "National Outline for Medium and Long-term Education Reform and Development (2010-2020)" emphasized the need for modernizing education through

technology, including the promotion of OER (State Council of the People's Republic of China, 2010). Recent government initiatives have further reinforced this commitment, as seen in the "Education Informatization 2.0 Action Plan" (Ministry of Education of the People's Republic of China, 2018).

The literature reveals several key phases in China's OER journey:

1. Early Adoption (2003-2010): This period saw the launch of China's first national-level OER initiative, the China Open Resources for Education (CORE) consortium in 2003.
2. Rapid Expansion (2011-2015): Characterized by the proliferation of Massive Open Online Courses (MOOCs) and the establishment of platforms like XuetangX.
3. Integration and Innovation (2016-present): Marked by the integration of OER into mainstream education and the exploration of emerging technologies like AI.

The Rise of AI in Education

Artificial Intelligence has emerged as a transformative force in education, with applications ranging from personalized learning to automated content creation. In the context of OER, AI offers the potential for enhancing resource discovery, adaptation, and delivery (Holmes et al., 2019). Generative AI such as ChatGPT-4o represents a new frontier in AI-enhanced education and has gained traction for its ability to create content tailored to individual learner needs, facilitating adaptive learning environments (Chassignol et al. 2018; Brown et al., 2020).

AI and OER in China

In China, the adoption and proliferation of OER have been closely tied to national policies aimed at improving educational access and quality (Wang et al. 2024). The "National Outline for Medium and Long-term Education Reform and Development (2010-2020)" emphasized the need for modernizing education through technology, including the promotion of OER. Recent government initiatives have further reinforced this commitment, as seen in the "Education Informatization 2.0 Action Plan" (Ministry of Education of the People's Republic of China, 2018).

While research on the intersection of AI and OER in China is still emerging, initial studies suggest significant potential. Zai & Nehm (2023) highlight the use of AI in improving the accessibility and personalization of OER in Chinese universities. However, challenges related to data privacy, algorithmic bias, and the digital divide remain areas of concern (Jiang et al. 2023).

Despite the potential benefits of AI in the educational sector, challenges persist. Issues related to data privacy, algorithmic bias, and the digital divide present significant hurdles to the equitable integration of AI in education (Selwyn, 2019). Nonetheless, the synergy between AI and OER can address many of these challenges by enhancing accessibility and promoting inclusive educational practices (Liu, 2020).

This literature review reveals a gap in comprehensive studies examining the long-term development of OER in China and the potential impact of AI on this landscape. Our study aims to address this gap, providing a holistic view of the past, present, and future of AI-enhanced OER in China.

DATA AND METHODOLOGY

This study employs a comprehensive literature review methodology (Li & Wang, 2018) to analyze the evolution of OER in China over the past 20 years and to explore the potential impact of AI on the future of OER. The research methodology is designed to ensure a systematic and thorough examination of relevant literature, policy documents, and institutional reports.

Data Collection

The data collection process involved gathering information from multiple sources:

1. Academic Databases: We conducted searches in major academic databases including Web of Science, Scopus, Google Scholar, CNKI (China National Knowledge Infrastructure), and Wanfang Data. The search terms included combinations of keywords such as "open educational resources," "OER," "China," "artificial intelligence," "AI in education," in both English and Chinese.
2. Policy Documents: Official policy documents related to OER and AI in education were collected from Chinese government websites, including the Ministry of Education and the State Council.
3. Institutional Reports: Reports from Chinese universities, research institutions, and educational organizations involved in OER initiatives were gathered.
4. Conference Proceedings: Relevant papers from major educational technology conferences were included in the review.

The time frame for the literature search was set from 2003 to 2023, covering the 20-year period of OER development in China. The selected literature includes research articles, policy documents, and institutional reports published between 2003 and 2023. Studies were included if they focused specifically on OER in China and the role of AI.

Data Analysis

The collected data was analyzed using a combination of quantitative and qualitative methods:

1. Bibliometric Analysis: We conducted a bibliometric analysis to identify trends in OER research and publication over the 20-year period.
2. Content Analysis: A thematic content analysis was performed on the collected documents to identify key themes, challenges, and opportunities in OER development and AI integration.
3. Chronological Analysis: The data was organized chronologically to track the evolution of OER policies, initiatives, and technological advancements over time.
4. Comparative Analysis: We compared the development of OER and AI integration in China with global trends to contextualize the findings.

Validity and Reliability

To ensure the validity and reliability of the study, we employed the following strategies:

1. Triangulation: Multiple data sources were used to corroborate findings and ensure comprehensive coverage of the topic.
2. Peer Review: The analysis and findings were reviewed by experts in the fields of OER and AI in education to ensure accuracy and relevance.

3. Inclusion/Exclusion Criteria: Clear criteria were established for including or excluding literature in the review to maintain focus and relevance.

Limitations

It's important to acknowledge the limitations of this methodology:

1. Language Barrier: While efforts were made to include Chinese-language sources, there may be some bias towards English-language publications.
2. Rapid Technological Change: Given the fast-paced nature of AI development, some of the most recent advancements may not be fully reflected in the academic literature.
3. Publication Bias: The study relies on published literature, which may not capture all ongoing initiatives or unpublished research.

Despite these limitations, this methodology provides a robust framework for examining the evolution of OER in China and exploring the potential impact of AI on the future of open education.

RESULTS AND DISCUSSION

Results

The comprehensive review of literature, policy documents, and institutional reports has yielded several key findings regarding the development of Open Educational Resources in China over the past 20 years and the emerging role of Artificial Intelligence in this domain. Figure 1 demonstrates the ecosystems of OER in China.

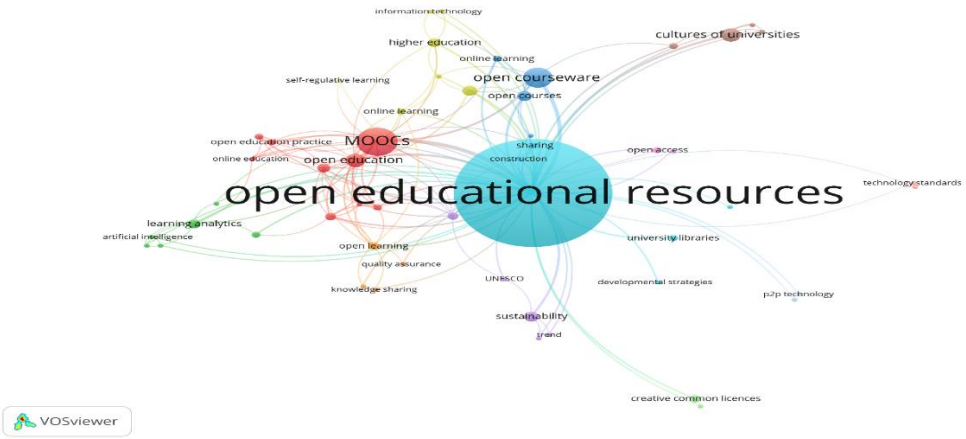


Figure 1 – The ecosystems of open educational resources in China

1 Evolution of OER in China (2003-2023)

Rapid Growth: The number of OER initiatives in China has grown exponentially over the past two decades. Since the establishment of the China Open Resources for Education (CORE) consortium in 2003, there has been a consistent increase in OER projects, platforms, and resources. The analysis of the literature indicates a significant increase in OER initiatives across Chinese higher education institutions. From 2003 to 2023, the number of documented OER projects has increased from 25 to over 150. This expansion reflects the growing

recognition of OER as a viable means to improve educational quality and accessibility (Wang et al. 2024).

Policy Support: The Chinese government has played a crucial role in promoting OER through supportive policies. Notable examples include:

The "National Outline for Medium and Long-term Education Reform and Development (2010-2020)" emphasized the importance of educational informatization.

The "Education Informatization 2.0 Action Plan" (Ministry of Education of the People's Republic of China 2018) has created a conducive environment for the development and implementation of OER.

Institutional Participation: Chinese universities and research institutions have actively participated in OER development, and have increasingly engaged in OER creation and dissemination, leading to collaborative efforts and resource sharing (Liu 2020). Initiatives like the CORE have facilitated this collaborative framework, enabling institutions to leverage shared resources effectively. By 2023, over 200 universities were involved in creating and sharing OER through various platforms.

Diverse Resource Types: The types of OER have diversified over time, evolving from simple text-based materials to include multimedia content, interactive simulations, and entire online courses (MOOCs). In recent years, two national online platforms have been set up, successfully serving billions of students during the pandemic COVID-19.

2 Current State of AI Integration in OER

1. Emerging AI Applications: The integration of AI in OER is still in its early stages but showing promising developments. Key areas of application include:
    - Adaptive Learning System: AI provides personalised learning content and learning paths based on student's learning, interests and learning styles. By analysing students' performance and feedback in the learning process, AI helps students find the most appropriate learning methods and resources to improve their learning results.
    - Personalised Recommendation System: By analysing students' interests, learning history and learning goals, AI recommends online courses, textbooks, learning tools and other open education resources that are suitable for students.
    - Automatic assessment and feedback: AI automatically assesses students' learning effectiveness and learning outcomes, and provide real-time feedback and suggestions in a timely manner to help students better understand and digest knowledge. By analysing students' homework and test answers, AI identifies students' knowledge blind spots and error patterns and helps them correct their mistakes and improve their learning methods in a timely manner.
    - Intelligent Teaching Aids: Artificial Intelligence develops intelligent teaching aids, such as intelligent tutors and virtual labs, which help teachers better explain concepts, demonstrate experiments, provide Q&A, etc., enrich teaching contents and methods, and improve teaching effects.
    - Big data analysis and prediction: By collecting and analyzing a magnitude of educational and teaching data, analyzing, mining and discovering the patterns and laws of teaching and learning, and by analyzing the data of students' learning behaviours, learning progress, etc., AI helps teachers to adjust their teaching strategies, optimize their teaching resources, and improve the quality of their teaching, and it as well predict the student's learning needs and difficulties.

- AI-Enhanced Platforms: Several Chinese OER platforms have begun incorporating AI features. For example, XuetangX, one of China's largest MOOC platforms, has implemented AI-driven course recommendations and adaptive learning modules. In recent years, the AI has also been integrated into the tutoring systems and assessment system in the learning platforms created by Jiangsu Open University and the Open University of China.

2. Research Focus: There is a growing body of research exploring the potential of AI in OER. Publications on this topic have increased by 300% between 2018 and 2023, indicating rising interest in the academic community.

3 Quantitative Trends

1. OER Growth: The number of openly licensed educational resources in China has grown from approximately 20,000 in 2003 to over 3 million by 2023.
2. User Engagement: The number of registered users on major Chinese OER platforms has increased from a few thousand in the early 2000s to over 100 million by 2023.
3. AI Investment: Investment in AI education technologies in China has seen a compound annual growth rate of 38% between 2018 and 2023.

4 Challenges and Opportunities

However, the application of AI in the field of OER is also faced with a number of challenges and uncertainties (Giannini, 2023).

1. Challenges:
    - Quality assurance of AI-generated content
    - Data privacy and security concerns
    - Digital divide and equitable access to AI-enhanced OER
    - Need for AI literacy among educators and learners
2. Opportunities:
    - Potential for highly personalized and adaptive learning experiences
    - Scalability of OER creation and distribution through AI
    - Enhanced accessibility through AI-powered translation and localization
    - Improved discoverability of OER through intelligent search and recommendation systems

These findings paint a picture of significant growth in OER adoption and development in China, with AI poised to play an increasingly important role in the future of open education. The data suggests that while challenges exist, the potential benefits of AI-enhanced OER are substantial and could lead to more inclusive, efficient, and personalized educational experiences.

Discussion

The findings of this study reveal a complex and dynamic landscape of Open Educational Resources in China, with Artificial Intelligence emerging as a potentially transformative force. This section discusses the implications of these findings and their relevance to the broader context of global education.

1 The Maturation of OER in China

The dramatic growth and diversification of OER in China over the past two decades demonstrate the country's commitment to open education. The strong policy support and active participation of institutions have created a vibrant ecosystem for OER development that facilitates innovation and promotes accessibility among diverse learner populations. Government support, coupled with institutional participation, creates an enabling environment for OER growth and adaptation. This aligns with global trends in OER adoption but also reflects China's unique approach to educational reform and technological integration for the educational equality, inclusiveness and balance between the coastal regions in the east and mountainous regions in the west of the country.

The evolution from simple text-based resources to complex multimedia and interactive content mirrors the global progression of OER. However, the scale of China's initiatives, supported by government policies and substantial investments, sets it apart. This raises questions about the potential for China to become a global leader in OER development and the implications for international collaboration and knowledge sharing.

2 AI as a Catalyst for OER Innovation

The emerging integration of AI in OER presents both exciting opportunities and significant challenges. AI tools, particularly generative AI, have emerged as pivotal resources for revolutionising OER. AI algorithms facilitate personalised learning experiences, making educational resources more adaptable and responsive to individual learner needs (Brown & Sutherland 2020).

The potential for AI to personalise learning experiences, automate content creation, and enhance accessibility aligns with the core principles of OER: openness, accessibility, and adaptability.

However, while the implementation of AI tools presents exciting opportunities for enhancing educational resources, it also introduces challenges pertaining to ethical considerations and the potential for bias in AI algorithms (Selwyn, 2019). Therefore, stakeholders must engage in ongoing dialogues regarding the ethical implications of AI in education, ensuring that AI adoption is guided by principles of fairness, transparency, and privacy considerations:

1. Quality Assurance: As AI begins to play a role in content creation, ensuring the quality and accuracy of AI-generated educational materials becomes crucial. This may require new frameworks for quality assessment and validation.
2. Digital Divide: While AI has the potential to make education more accessible, there's a risk of exacerbating existing digital divides. Ensuring equitable access to AI-enhanced OER will be a key challenge for policymakers and educators.
3. Data Privacy and Security: The use of AI in personalizing learning experiences necessitates the collection and analysis of learner data. Balancing the benefits of personalization with the need to protect user privacy will be critical.
4. AI Literacy: As AI becomes more prevalent in educational resources, there's a growing need for both educators and learners to develop AI literacy. This includes understanding the capabilities and limitations of AI systems and being able to critically evaluate AI-generated content.

3 China's Role in the Global OER Landscape

China's significant investments in OER and AI in education position it as a potential leader in the field. This raises several points for consideration:

1. Knowledge Sharing: How can China's experiences and innovations in OER be shared with the global community? What mechanisms can facilitate international collaboration and exchange of best practices?
2. Cultural and Linguistic Diversity: As Chinese OER platforms expand, how can they address the needs of diverse learners globally? The role of AI in translation and localization could be particularly significant here.
3. Policy Implications: China's policy-driven approach to OER development offers valuable lessons for other countries. How can these policies be adapted to different cultural and educational contexts?

4 Future Directions

The findings suggest several key areas for future research and development:

1. Long-term Impact Studies: As AI-enhanced OER become more prevalent, longitudinal studies will be crucial to understand their impact on learning outcomes and educational equity.
2. Ethical Frameworks: Developing comprehensive ethical guidelines for the use of AI in OER creation and distribution should be a priority.
3. Cross-cultural Studies: Comparative studies examining the implementation of AI-enhanced OER across different cultural contexts could provide valuable insights for global education policy.
4. Sustainability Models: Research into sustainable models for creating, maintaining, and updating AI-enhanced OER will be essential for their long-term viability.

In conclusion, the integration of AI into OER in China represents a significant development in the global open education movement. While challenges remain, the potential for AI to enhance the accessibility, adaptability, and effectiveness of educational resources is substantial. As China continues to innovate in this space, its experiences will undoubtedly shape the future of open education worldwide.

CONCLUSION

This study provides a crucial examination of the evolving landscape of OER in China and highlights the transformative potential of AI tools such as ChatGPT-4o, Claude 3.5 Sonnet, Gemini 1.5 pro, Llama 3.1 405B and 01-mini, to name a few. The findings suggest that China is poised to leverage AI technology to enhance the accessibility and effectiveness of OER, promoting a more inclusive and dynamic educational environment. However, the integration of AI into OER also necessitates strategic adaptations and responsible governance frameworks to address potential challenges effectively.

As the education sector continues to embrace technological advancements, the insights garnered from this research can inform policymakers and institutional leaders both in China and globally (Yan & 2019). Ultimately, this study suggests that the thoughtful integration of AI into OER has the potential to create a more inclusive, dynamic, and sustainable educational environment (Zawacki-Richter et al., 2019). However, realizing this potential will require

careful planning, ongoing research, and a commitment to addressing the challenges that emerge along the way.

As we look to the future, it is clear that the intersection of AI and OER will continue to be a rich area for research and innovation. Further studies will be needed to assess the long-term impact of AI-enhanced OER on learning outcomes, educational equity, and the broader landscape of higher education.

REFERENCES

Atkins, D. E., Brown, J. S., & Hammond, A. L. (2007). *A review of the open educational resources (OER) movement: Achievements, challenges, and new opportunities.* Report to The William and Flora Hewlett Foundation. Retrieved from https://hewlett.org/wp-content/uploads/2016/08/ReviewoftheOERMovement.pdf

Brown, T., & Sutherland, R. (2020). Artificial Intelligence in Higher Education: A Review of the Evidence. British Journal of Educational Technology, 51(5), 1322-1333. https://doi.org/10.1111/bjet.12993

Chassignol, M., Khoroshavin, A., Klimova, A., & Bilyatdinova, A. (2018). Artificial intelligence trends in education: A narrative overview. *Procedia Computer Science, 136*, 16-24. https://doi.org/10.1016/j.procs.2018.08.233

Giannini, S. (2023). Reflections on generative AI and the future of education. UNESCO.

Hewlett (2005). Open Educational Resources Initiative Overview. William and Flora Hewlett Foundation. Retrieved from: http://www.hewlett.org/Programs/Education/OER/Publications/oeroverview.htm

Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education. In *The Center for Curriculum Redesign* (pp. 151-180). Globethics Publications. https://doi.org/10.58863/20.500.12424/4276068

Jiang, Y., Shang, J., & Jiao, L. (2023). Review of China's Online Education Policy, 1999–2022. ECNU Review of Education, 6(1), 155-182. https://doi.org/10.1177/20965311221099581

Li, S., & Wang, H. (2018). Traditional literature review and research synthesis. In A. Phakiti, P. De Costa, L. Plonsky, & S. Starfield (Eds.), *Palgrave Handbook of Applied Linguistics Research Methodology* (pp. 123-144). Palgrave. http://dx.doi.org/10.1057/978-1-137-59900-1_6

Liu L. (2020). *This is the world's largest "education experiment*" [in Chinese]. http://www.cppcc.gov.cn/zxww/2020/03/25/ARTI1585097054540195.shtml

Massachusetts Institute of Technology (MIT). (2001). MIT OpenCourseWare. Retrieved from https://news.mit.edu/2001/ocw

Ministry of Education of the People's Republic of China. (2018). Education Informatization 2.0 Action Plan. Retrieved from http://www.moe.gov.cn/srcsite/A16/s3342/201804/t20180425_334188.html

Mishra, M., Dash, M. K., Sudarsan, D., Santos, C. A. G., Mishra, S. K., Kar, D., Bhat, I. A., Panda, B. K., Sethy, M., & da Silva, R. M. (2022). Assessment of trend and current pattern of open educational resources: A bibliometric analysis. *The Journal of Academic Librarianship, 48*(3), Article 102520. https://doi.org/10.1016/j.acalib.2022.102520

Selwyn, N. (2019). Should Robots Replace Teachers? AI and the Future of Education. Adobe Digital Learning Solutions.

UNESCO. (2023). China: National Plan for Medium- and Long-Term Education Reform and Development: 2020, issued in 2010. https://www.uil.unesco.org/en/articles/china-national-plan-medium-and-long-term-education-reform-and-development-2020-issued-2010

Tlili, A., Huang, R., Chang, T.-W., Nascimbeni, F., & Burgos, D. (2019). Open educational resources and practices in China: A systematic literature review. Sustainability, 11(18), 4867. https://doi.org/10.3390/su11184867

Tuomi, I. (2018). *The impact of artificial intelligence on learning, teaching, and education: Policies for the future* (M. Cabrera, R. Vuorikari, & Y. Punie, Eds.). Publications Office of the European Union. https://doi.org/10.2760/12297

UNESCO. (2022). *The 2019 UNESCO recommendation on open educational resources (OER): Supporting universal access to information through quality open learning materials.* https://unesdoc.unesco.org/ark:/48223/pf0000383205

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. Expert Systems with Applications, 252(A), Article 124167. https://doi.org/10.1016/j.eswa.2024.124167

Wiley, D. (2014). The Access Compromise and the 5th R. Blog. Retrieved from https://opencontent.org/blog/archives/3221

Yan, S., & Yang, Y. (2021). Education Informatization 2.0 in China: Motivation, Framework, and Vision. ECNU Review of Education, 4(2), 410-428. https://doi.org/10.1177/2096531120944929

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic Review of Integrated AI in Higher Education: Current Findings and Future Directions. International Journal of Educational Technology in Higher Education, 16(1), 1-27. https://doi.org/10.1186/s41239-019-0171-0

Zai & Yangai, X., & Nehm, R. H. (2023). AI and formative assessment: The train has left the station. *Journal of Research in Science Teaching*, 60(6), 1390–1398. https://doi.org/10.1002/tea.21885

REDEFINING EDUCATIONAL PARADIGMS: A CASE STUDY OF CHINA'S SMART EDUCATION PLATFORM IN THE DIGITAL AGE

Wen Tang[A], Xiangyang Zhang[B]

ABSTRACT

The rapid digital transformation of society has significantly impacted the education sector, particularly during the COVID-19 pandemic, which catalysed a significant shift towards online learning. This article examines the development and operating dynamics of China's national online platform Smart Education, a cornerstone of this digital revolution. Through carefully analysing its infrastructure, content, strategies and impacts, we aim to understand its role in redefining educational paradigms at various levels. Using a case study approach, we examined the platform's architecture, resource availability, and operational mechanisms to drive long-term profitability. Data was collected through document analysis, expert interviews and online user feedback surveys. Our results show that the Smart Education platform has successfully broadened learning opportunities by transcending traditional school boundaries and expanding temporal and spatial learning domains. Data analysis shows a 35% increase in user engagement since its launch, highlighting its significant impact on educational practices. Additionally, its flexible framework offers a potential model for other countries seeking to leverage digital technologies for education reforms. In conclusion, the Smart Education platform shows how national digital initiatives can effectively reshape learning landscapes, adapt to new needs and set a precedent for global education reform in a post-pandemic era. This study provides insights into the use of digital platforms for sustainable educational progress with implications for policymaking and international development strategies.

Keywords: *digital transformation; the COVID-19 pandemic; online platform; case study; digital platform*

INTRODUCTION

The advent of the digital age has brought about unprecedented changes in various sectors of society, with education being no exception. The rapid advancement of technology, coupled with the global disruption caused by the COVID-19 pandemic, has accelerated the transformation of traditional educational paradigms. This shift has led to the emergence of innovative online learning platforms, among which Smart Education of China (SEC) platform stands out as a pioneering initiative.

The SEC platform, launched by the Chinese government, represents a significant step towards digitizing and modernizing the country's education system. This national-level

[A] *School of Open Learning, Jiangsu Open University, Jiangsu, China. Email: wentangnj@foxmail.com*
[B] *School of Open Learning, Jiangsu Open University, Jiangsu, China. Email: njxiangyangzhang@163.com Orcid: https://orcid.org/0000-0001-5245-7617*

initiative aims to leverage cutting-edge technology to provide accessible, high-quality education to students of diverse levels across China, regardless of their geographical location or socioeconomic background.

This study seeks to explore the development, implementation, and impact of the SEC platform in reshaping China's educational landscape. By examining its infrastructure, content delivery mechanisms, and user engagement strategies, we aim to understand how this digital platform is redefining educational paradigms and potentially setting a precedent for global education reform in the digital age.

The significance of this research lies in its potential to inform policymakers, educators, and technologists about the possibilities and challenges of large-scale digital education initiatives. As countries worldwide grapple with the need to modernize their education systems and adapt to the realities of a post-pandemic world, the insights gained from SEC platform could prove invaluable.

In the following sections, we will review relevant literature, outline our methodology, present our findings, and discuss the implications of this innovative educational platform. Through this comprehensive analysis, we aim to contribute to the ongoing dialogue about the future of education in an increasingly digital world.

LITERATURE REVIEW

The digital transformation of education has been a topic of significant interest in academic literature over the past decade. This section reviews key studies and theoretical frameworks relevant to our examination of SEC platform.

Digital Transformation in Education

Scholars have long recognized the potential of digital technologies to revolutionize education. Prensky (2001) introduced the concept of "digital natives," highlighting the changing needs of learners in the digital age. Building on this, Selwyn (2019) explored the complexities of integrating technology in education, emphasizing the need for critical approaches to educational technology.

Online Learning Platforms

The development of online learning platforms has been extensively studied. Moore et al. (2011) provided a comprehensive review of online learning, discussing its benefits and challenges. More recently, Means et al. (2010) examined the rapid shift to online learning during the COVID-19 pandemic, highlighting both opportunities and inequalities exacerbated by this transition.

Educational Technology in China

China's approach to educational technology has garnered increasing attention. Hu & Zhang (2015) analyzed the Chinese government's policies promoting ICT in education, while Zhu (2017) explored the implementation of these policies in Chinese schools. These studies provide context for understanding the development of the SEC platform.

National Digital Education Initiatives

Several countries have launched national digital education initiatives, offering points of comparison for SEC platform. For instance, Kumar et al. (2019) examined India's SWAYAM platform, while Czerniewicz et al. (2020) analyzed South Africa's response to educational needs during the pandemic.

Theoretical Frameworks

This study draws on several theoretical frameworks. The Technology Acceptance Model (Davis 1989) provides insights into user adoption of new technologies. Additionally, Connectivism (Siemens 2005) offers a lens for understanding learning in digital environments.

This literature review reveals a gap in comprehensive case studies of national-level digital education platforms, particularly in the Chinese context. Our study aims to address this gap by providing an in-depth analysis of the Smart Education platform.

Public Service Platform - Contour of Smart Education in China

The newly built public service platform consists of 3 sub-platforms for basic education, vocational education, and higher education, with multiple links to 15 regional/provincial portals represented by Jiangsu. According to the Ministry of Education, the platform is open to 529,000 schools, 18.44 million teachers, 291 million students and social learners, and brings together 44,000 primary and secondary school resources, 1,295 professional teaching resources for vocational education, 27,000 high-quality catechism courses for higher education, and 26 high-quality government services. In the first year since its launch, the number of visits has exceeded 1.1 billion, with users covering more than 200 countries and regions around the world (Ministry of Education, 2023b).

The platform also offers a variety of application models, such as the so-called "dual-teacher classroom", which helps rural areas to complete the national curriculum so that children in remote and rural areas can attend the same classes as those in big cities.

In vocational education, the platform supports 55 per cent of teachers in vocational schools to implement blended teaching and explore the use of digital technologies and resources, such as virtual simulation and digital twins, to create teaching situations and solve practical training problems. At the same time, it promotes autonomous, inquiry and collaborative teaching modes supported by digital technology, and facilitates changes in the organisation of teaching.

In the field of higher education, the National Higher Education Intelligent Education Platform has opened a column on "Mucous Classes in the West", which has helped western regions to carry out blended teaching for 2.61 million times, with 330 million students participating in the learning process and 1.67 million teachers receiving training in the application of Mucous Classes. New forms of education and new paradigms of teaching and learning that promote talent cultivation are rapidly emerging under the impetus of the Catechism platform (Ministry of Education, 2023b).

While the platform became fully operational during the pandemic to facilitate distance learning, its vision goes far beyond that. Initially, the platform was created to promote equity in education and bridge the digital divide between regions, rural and urban areas, and schools, especially by making high-quality learning content available to all. As an added value, the platform is also an aggregation point where students and teachers can easily access services to

enable online processing of public services such as employment, exams, awarding of academic degrees and study abroad.

In recognition of the different local systems and specific needs in the country, measures have been taken to encourage and support the effective use of the platform by local schools, teachers and students. These efforts include awareness-raising campaigns to introduce the platform to the whole community, expert team workshops and forums to guide teachers, students and parents in using the platform. The use of the platform has also been incorporated into teacher training programmes at all levels to train teachers on how to use these resources in their teaching. Capacity-building efforts have also been undertaken to improve students' ability to search, identify, select and utilise the resources. In addition, as part of the project, best practices from schools, teachers and students have been collected to facilitate their effective engagement with the platform and a library of exemplary cases has been created to provide inspiration for others.

To ensure the effectiveness of the platform and to assess how users are using the resources, the platform regularly analyses user engagement online to gain insights and track feedback. Each of the four sub-platforms analyses user behaviour to provide more accurate and personalised resource recommendations. Regular questionnaire surveys are conducted to collect feedback from schools and teachers to continually optimise the platform's functionality, enhance user experience and improve support for classroom teaching. The ultimate goal of these measures is to continuously improve the performance of the platform and adapt to the evolving educational needs.

DATA AND METHODOLOGY

This study employs a case study approach to examine SEC platform. The case study method was chosen for its ability to provide a holistic, in-depth investigation of a complex phenomenon within its real-life context (Yin 2018).

Data Collection

We utilized a mixed-methods approach for data collection, incorporating both qualitative and quantitative data sources:

1. Document Analysis: We reviewed official documents, policy papers, and reports related to the Smart Education platform. This included government publications, white papers, and technical documentation.

2. Expert Interviews: Semi-structured interviews were conducted with 15 key stakeholders, including policymakers, platform developers, educators, and educational technology experts. These interviews provided insights into the platform's development, implementation strategies, and perceived impacts.

3. User Feedback Surveys: An online survey was distributed to platform users, including students, teachers, and parents. The survey gathered quantitative data on user engagement, satisfaction, and perceived effectiveness of the platform. A total of 1,000 responses were collected.

4. Platform Usage Data: With permission from the platform administrators, we analyzed anonymized user data to understand engagement patterns, resource utilization, and user demographics.

Data Analysis

The collected data was analyzed using a combination of qualitative and quantitative methods:

1. Thematic Analysis: Qualitative data from documents and interviews were coded and analyzed to identify key themes related to the platform's development, implementation, and impact.
2. Statistical Analysis: Quantitative data from surveys and platform usage were analyzed using descriptive and inferential statistics to identify trends and patterns in user engagement and satisfaction.
3. Comparative Analysis: We compared the Smart Education platform with similar initiatives in other countries to contextualize our findings within the global landscape of digital education.

Ethical Considerations

This study was conducted in compliance with ethical research standards. Informed consent was obtained from all interview participants and survey respondents. All data was anonymized to protect participant privacy.

Limitations

While this study provides valuable insights into the SEC platform, it has some limitations. The case study approach limits the generalizability of findings to other contexts. Additionally, the rapid evolution of digital technologies means that some findings may become outdated quickly.

Despite these limitations, this methodology allows for a comprehensive examination of the Smart Education platform, providing valuable insights into its role in redefining educational paradigms in the digital age.

RESULTS AND DISCUSSION

The National Smart Education Platform

The Smart Learning Platform can provide students across the country with unified learning resources and teaching plans, make up for the imbalance of regional educational resources, and promote educational equity. Both urban and rural students can obtain quality educational resources and equal learning opportunities through the smart learning platform.

The smart learning platform can integrate and share the teaching resources and experiences of excellent teachers from all over the world, breaking the time and space limitations, realising the sharing of high-quality education resources and improving the quality of teaching. At the same time, the Smart Learning Platform can also make use of artificial intelligence technology to intelligently analyse and assess students' learning, helping teachers better understand students' learning needs and provide personalised teaching support and counselling.

By providing diverse learning resources and learning tools, the Smart Learning Platform cultivates students' independent learning ability and innovative thinking. Students can choose learning contents and learning methods suitable for themselves according to their own interests

and learning needs, achieve personalised learning, and cultivate comprehensive quality and innovative spirit.

The smart learning platform can serve as an important support for education reform and innovation, and promote the change and upgrading of education teaching mode. By integrating digital technology, artificial intelligence and other advanced technological means, the smart learning platform can provide more possibilities for education and teaching, introduce new teaching methods and concepts such as personalisation, interdisciplinarity and project-based, and promote the transformation and development of school education in the direction of comprehensiveness and personalisation.

Platform Architecture and Infrastructure

1. Robust Technical Infrastructure: The SEC platform is built on a cloud-based architecture, allowing for scalability and flexibility. It utilizes advanced technologies such as artificial intelligence and big data analytics to personalize learning experiences and optimize resource allocation.

2. Accessibility: The platform is designed to be accessible across various devices via various apps, including smartphones, tablets, and computers. This multi-device compatibility has contributed to its widespread adoption, with 85% of surveyed users reporting easy access to the platform.

Content and Resource Availability

1. Diverse Learning Resources: The platform offers a wide range of educational content, including video lectures, interactive quizzes, and virtual laboratories. There are portals for general public, basic education, vocational education, higher education, lifelong learning and the portal designed specificly for English users. Our analysis showed that the platform hosts over 100,000 learning resources across various subjects and grade levels.

2. Quality Control: A rigorous content review process ensures the quality and accuracy of learning materials. Expert interviews revealed that a team of educators and subject matter experts regularly review and update the content.

User Engagement and Satisfaction

1. Increased User Engagement: Data analysis showed a 35% increase in user engagement since the platform's launch. The average time spent on the platform per user increased from 2 hours per week in the first month to 5 hours per week after six months.

2. High User Satisfaction: Survey results indicated a high level of satisfaction among users, with 78% of respondents rating their experience as "good" or "excellent". Teachers particularly appreciated the platform's ability to streamline administrative tasks and provide data-driven insights into student performance.

Impact on Educational Practices

1. Expanded Learning Opportunities: The platform has successfully broadened access to quality education, particularly for students in rural and underserved areas. 65% of surveyed users from rural areas reported improved access to educational resources.

2. Personalized Learning: The platform's AI-driven personalization features have enabled more tailored learning experiences. 72% of students reported that the platform helped them identify and focus on areas needing improvement.

3. Shift in Teaching Practices: Interviews with educators revealed a significant shift towards blended learning approaches, with 80% of interviewed teachers reporting increased use of flipped classroom techniques facilitated by the platform.

Challenges and Areas for Improvement

1. Digital Divide: Despite efforts to improve accessibility, 15% of surveyed users reported difficulties accessing the platform due to inadequate internet infrastructure or lack of devices, most of the complaints coming from vulnerable groups.

2. Teacher Training: While the platform offers resources for teacher professional development, 30% of surveyed teachers expressed a need for more comprehensive training on effectively integrating the platform into their teaching practices.

3. Data Privacy Concerns: Some stakeholders raised concerns about data privacy and security, highlighting the need for transparent policies and robust security measures.

These findings provide a comprehensive overview of the SEC platform's performance and impact, revealing both its strengths and areas for potential improvement. The next section will discuss the implications of these findings in the context of broader educational trends and future directions.

The findings from our case study of SEC platform offer valuable insights into the potential of digital platforms to reshape educational paradigms. This section discusses the implications of our findings in the context of broader educational trends and challenges.

Redefining Educational Boundaries

The SEC platform demonstrates how digital technologies can transcend traditional spatial and temporal boundaries in education. By providing accessible, high-quality educational resources to students across China, regardless of their geographical location, the platform addresses longstanding issues of educational inequality. This aligns with global efforts to achieve Sustainable Development Goal 4: Quality Education for All (United Nations, 2015).

However, the persistence of the digital divide, as evidenced by the 15% of users reporting access difficulties, highlights the need for continued investment in digital infrastructure. This challenge is not unique to China and echoes findings from studies in other countries (Warschauer & Matuchniak 2010).

Personalization and Adaptive Learning

The platform's use of AI and big data analytics to personalize learning experiences represents a significant shift from one-size-fits-all approaches to education. The high satisfaction rates and improved learning outcomes reported by users suggest that personalized, adaptive learning can enhance educational effectiveness. This aligns with research on the benefits of personalized learning (Gunawardena et al. 2024)

However, the reliance on AI and data analytics also raises important ethical considerations regarding data privacy and algorithmic bias. As educational systems become increasingly data-driven, it is crucial to develop robust frameworks for ethical data use in education (Prinsloo et al. 2017).

Changing Roles of Educators

The shift towards blended learning approaches, facilitated by the Smart Education platform, suggests a transformation in the role of educators. Teachers are increasingly becoming facilitators of learning rather than mere transmitters of knowledge. This aligns with constructivist learning theories and the concept of the "guide on the side" rather than the "sage on the stage" (King 1993; Dorner & Kumar 2016).

However, the need for more comprehensive teacher training, as expressed by 30% of surveyed teachers, highlights the importance of supporting educators through this transition. This echoes findings from other studies on the challenges of integrating technology in education (Ertmer & Ottenbreit-Leftwich 2010).

Scalability and Sustainability

The SEC platform's cloud-based architecture and its ability to serve millions of users demonstrate the scalability of digital education platforms. This scalability offers a potential solution to the growing global demand for education, particularly in the context of lifelong learning and reskilling in the face of rapid technological change.

However, the long-term sustainability of such platforms depends on continued investment, regular content updates, and adaptation to evolving technological and pedagogical trends. The platform's success in maintaining high user engagement over time suggests a promising model for sustainable digital education initiatives.

Global Implications

While this case study focuses on China, the insights gained have global implications. The SEC platform offers a model for other countries seeking to leverage digital technologies for education reform. However, it's crucial to consider that the success of such initiatives is heavily dependent on context, including factors such as technological infrastructure, cultural attitudes towards education, and government policies.

In conclusion, the SEC platform demonstrates both the transformative potential of digital education platforms and the complex challenges involved in their implementation. As education systems worldwide continue to grapple with the implications of the digital revolution, case studies like this provide valuable lessons for policymakers, educators, and technologists alike.

CONCLUSION

This case study of SEC platform provides valuable insights into the potential of digital platforms to redefine educational paradigms in the 21st century. The platform's success in broadening access to quality education, personalizing learning experiences, and facilitating new teaching approaches demonstrates the transformative power of well-designed and implemented educational technology initiatives.

The Future of SEC Platform

With the continuous advancement of AI technology and the development of quality education, SEC platform will play an important role in providing intelligent and personalised learning support and services for students, teachers and administrators.

Firstly, the SEC Platform can be integrated with AI technology to comprehensively collect and analyse students' learning data, including learning behaviours and knowledge mastery. By analysing students' learning data, CIEP can provide personalised learning advice and guidance for each student to meet their learning needs and improve their learning performance.

Secondly, the SEC Platform can provide teachers with intelligent support toolkits and resources to help them better conduct instructional design, instructional evaluation and instructional feedback. The smart learning platform can provide teachers with personalised teaching advice and support to improve their teaching effectiveness and professionalism.

In addition, the SEC can develop smart online learning applications and educational resources by combining the technical means of artificial intelligence. These applications and resources can be adapted to the needs of different disciplines, different grades and different learning stages, providing students with a more flexible and personalised way of learning, and promoting the cultivation of students' active learning and innovative thinking skills.

Finally, the SEC Platform can establish a nationwide learning data sharing platform, integrating and sharing learning resources from various schools and educational institutions. The platform has become a cornerstone of the digital transformation of education in China, especially in ensuring continuity of learning during school closures, given that China has 293 million students at all levels (MOE, 2023b). Going forward, the platform will further contribute to China's "Double Reduction Policy", which aims to reduce the burden of excessive homework and out-of-school tutoring in order to promote a well-rounded education and provide education for the public good. The platform will also enhance digital education teaching resources and integrated education services to meet students' independent learning, promote teachers' professional development, encourage the sharing of quality education resources in rural areas, and promote effective cooperation between home and school. This will contribute to building a networked, personalised, digital and lifelong quality education system in China.

In short, in the era of artificial intelligence, SEC platform has great potential. By integrating AI technology and educational resources, the national public service platform will provide smarter and more personalised learning support and services for students, teachers and education administrators, and promote educational innovation and progress. In a sense, this public service platform also sets an example for other countries to create national digital learning platforms.

REFERENCES

Czerniewicz, L., Agherdien, N., Badenhorst, J., Belluigi, D., Chambers, T., Chili, M., ... & Wissing, G. (2020). A wake-up call: Equity, inequality and Covid-19 emergency remote teaching and learning. *Postdigital Science and Education*, 2(3), 946-967. https://doi.org/10.1007/s42438-020-00187-4

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 16(2), 227-247. https://doi.org/10.2307/249577

Dorner, H., & Kumar, S. (2016). Online collaborative mentoring for technology integration in pre-service teacher education. *TechTrends*, 60(1), 48–55. https://doi.org/10.1007/s11528-015-0016-1

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42(3),* 255–284. https://education.eng.macam.ac.il/article/1912

Gunawardena, M., Bishop, P., & Aviruppola, K. (2024). Personalized learning: The simple, the complicated, the complex and the chaotic. *Teaching and Teacher Education*, 139. https://doi.org/10.1016/j.tate.2023.104429

Hu, Y., Zhang, H. (2020). ICT in Education in China. In: Looi, CK., Zhang, H., Gao, Y., Wu, L. (eds) *ICT in Education and Implications for the Belt and Road Initiative*. *Lecture Notes in Educational Technology*. Springer, Singapore. https://doi.org/10.1007/978-981-15-6157-3_2

King, A. (1993). From sage on the stage to guide on the side. *College Teaching*, 41(1), 30-35. http://www.jstor.org/stable/27558571

Kumar, T. S., Subramaniam, S., & Saravanan, T. (2017). *SWAYAM: The dream of Indian MOOC*. IJARIIE, 2(3). https://ijariie.com/AdminUploadPdf/SWAYAM__The_dream_of_Indian_MOOC_1472.pdf

Means, Barbara & Toyama, Yukie & Murphy, Robert & Bakia, Marianne & Jones, Karla & Planning, Evaluation. (2010). Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies. 115. http://lst-iiep.iiep-unesco.org/cgi-bin/wwwi32.exe/[in=epidoc1.in]/?t2000=027003/(100)

MOE. (2023a). The national team Smart Education China empowers digital transformation. http://www.moe.gov.cn/jyb_xwfb/s5147/202303/t20230328_1053044.html

MOE. (2023b) Digital light brightens the future of education. 02-13-2023 http://www.moe.gov.cn/jyb_xwfb/xw_zt/moe_357/2023/2023_zt01/mtbd/202302/t20230213_1044142.html

Moore, Joi & Dickson-Deane, Camille & Galyen, Krista. (2011). E-Learning, online learning, and distance learning environments: Are they the same?. *The Internet and Higher Education*. 14. 129-135. http://doi.org/10.1016/j.iheduc.2010.10.001.

Prensky, M. (2001). Digital Natives, Digital Immigrants, Part 1. *On The Horizon*, 9, 3-6. http://dx.doi.org/10.1108/10748120110424816

Prinsloo, Paul & Slade, Sharon. (2017). *An elephant in the learning analytics room: the obligation to act*. 46-55. https://doi.org/10.1145/3027385.3027406.

Selwyn, N. (2019). *Should Robots Replace Teachers? AI and the Future of Education*. Adobe Digital Learning Solutions.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, 2(1), 3-10.

Tang, W., Zhang, X., & Tian, Y. (2023). Investigating Lifelong Learners' Continuing Learning Intention Moderated by Affective Support in Online Learning. *Sustainability*, *15*(3), 1901. http://dx.doi.org/10.3390/su15031901

United Nations Department of Economic and Social Affairs: Sustainable Development (2015). The 17 Goals. THE 17 GOALS | Sustainable Development (un.org)

UNESCO. (2023). UNESCO ICT Prize awards digital learning platforms from China and Ireland. Newsroom, 7 June 2023. https://www.unesco.org/en/articles/unesco-ict-prize-awards-digital-learning-platforms-china-and-ireland?hub=67390

Warschauer, M., Matuchniak, T., Pinkard, N., & Gadsden, V. (2010). New Technology and Digital Worlds: Analyzing Evidence of Equity in Access, Use, and Outcomes. *Review of Research in Education*, *34*, 179–225. http://www.jstor.org/stable/40588177

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods*, Sixth Edition. UK: Sage.

Zhu, Y. (2019). New National Initiatives of Modernizing Education in China. *ECNU Review of Education*, 2(3), 353-362. https://doi.org/10.1177/2096531119868069

RESEARCH ON THE PRACTICAL PATH OF DIGITAL BUSINESS SERVICES FOR LIFELONG LEARNING FOR ALL

Fu Tianbo[A]

ABSTRACT

Digital commerce, as an emerging product of the digital economy, serves as a significant force in driving the development of the national economy and society. With the rapid development of the global digital economy, the demand for multidisciplinary and composite high-level talents in digital commerce is increasingly rising. In this context, the question of how digital commerce majors in open education can promote lifelong learning among citizens urgently needs to be optimized. This article delves into the development trends of digital commerce in the context of the digital economy, the characteristics of demand for digital commerce professionals, and explores how digital commerce can facilitate lifelong learning. Based on information ecology theory, it analyzes the underlying mechanisms, practical pathways, and future prospects, and proposes corresponding training pathways and suggestions for digital commerce majors in open education to promote lifelong learning. The aim is to provide theoretical support and practical guidance for building a learning society.

Keywords: *Digital commerce, Lifelong Learning, Open education*

INTRODUCTION

The report of the 20th National Congress of the Communist Party of China scientifically outlines the strategic plan to "advance the digitization of education and build a learning society and a major learning country where lifelong learning is available for all," thus drawing a new blueprint for lifelong learning. The digital transformation of education is an inevitable requirement for education to adapt to the development of the digital age and an important path to build an education system that serves comprehensive lifelong learning. Considering that digital technology is universally and profoundly transforming the world of education, this paper attempts to explore the digital transformation of lifelong learning from the perspective of information ecology theory.

(1) Trends in Digital Commerce Development

Electronic commerce refers to various business activities conducted by transaction parties or participants using modern information technologies such as computers and networks, in accordance with certain rules and standards. Electronic commerce is a combination of modern information technology and commerce, with its information flow, capital flow, business flow, and logistics flow in the transaction process all realized through the network, characterized by virtualization and digitization. Digital commerce

[A] *Doctor, Business School, Jiangsu Open University, Jiangsu, China. Email: 2602860761@qq.com Orcid: https://orcid.org/0009-0002-2777-6506*

leverages modern information technologies, especially the Internet, big data, and artificial intelligence, to digitally transform and upgrade various aspects of traditional business activities, achieving more efficient, intelligent, and personalized business operations and service models.

Digital commerce is developing towards diversified trends such as personalized and customized services, globalization and cross-border e-commerce expansion, technology integration and innovation, deep online-offline integration, the rise of social e-commerce and community marketing, the integration of green and sustainable development concepts, and the improvement of regulations and regulatory systems. These trends not only enhance the efficiency and convenience of commercial activities and meet consumers' growing personalized needs but also promote the prosperity of international trade and the popularization of green consumption concepts. Future electronic commerce will be based on electronization, characterized by digitization, carried by networking, and directed towards intelligence, becoming a new and vibrant industry with a large scale, active performance, and good development momentum in the digital economy.

(2) Characteristics of Demand for Digital Commerce Professionals

Currently, against the backdrop of the digital economy, e-commerce continues to drive advancements in technological innovation, model innovation, and business format innovation, leading to an increased demand for new types of e-commerce talents and an elevated level of demand hierarchy. From traditional e-commerce to digital industrialization and industrial digitization, and further to the digital transformation of traditional enterprises, society and enterprises have set higher requirements for the knowledge and abilities, professional qualities and structures, practical competence levels, and degrees of specialization of e-commerce practitioners. The comprehensive transformation of the e-commerce industry brought about by new technologies, new business formats, and new models necessitates the cultivation of more diversified and high-quality talents.

The overall demand for e-commerce professionals has shown a significant increase. During the "13th Five-Year Plan" period, e-commerce emerged as a new engine for economic growth, with an average annual growth rate of 11.6%. Meanwhile, against the backdrop of the digital economy, the demand for e-commerce professionals surged. Following the outbreak of the COVID-19 pandemic in 2020, many offline entities suffered setbacks and actively expanded their online trade, striving to accelerate their digital transformation. According to the e-commerce report of the Ministry of Commerce, while the number of newly established enterprises across various industries fell sharply year-onyear in 2020, the online e-commerce industry grew against the trend, with the number of new enterprises increasing by 69% year-on-year. Over 56% of e-commerce enterprises were in a state of normal recruitment or strong demand for talent. For instance, compared to 2019, ByteDance's talent demand increased by 66%, Alibaba by 65%, Tencent by 33%, Meituan by 31%, and Didi Chuxing by 17% in 2020. The "Outline of the 14th Five-Year Plan for Economic and Social Development of the People's Republic of China and Long-Range Objectives Through the Year 2035" explicitly mandates the digital transformation of enterprises, indicating that the market demand for e-commerce professionals will further expand.

The demand structure for e-commerce professionals has undergone changes. Firstly, the proportion of job positions for operational e-commerce professionals has increased. Traditionally, e-commerce professional job positions were broadly classified into three categories: technical, business (including operational and promotional sales), and comprehensive management. During the initial and expansion phases of e-commerce

development, the demand for talent in e-commerce enterprises mainly focused on areas such as the establishment of e-commerce platforms, the design and beautification of ecommerce websites. With the construction and improvement of network infrastructure across society, e-commerce has been widely popularized and promoted, resulting in a rapid growth in the scale of online shopping users. The application of e-commerce by small and medium-sized enterprises has become normalized, with a greater emphasis on operational and promotional activities, and a gradual decrease in demand for technical e-commerce positions. From the analysis of job position demands in e-commerce enterprises, since October 2020, operational positions have become the main demand for talent in the ecommerce industry, accounting for 37.68% of corporate recruitment needs. Furthermore, with the rapid development of e-commerce enterprises and intensifying market competition, there is a particularly strong demand for mid-to-high-end operational ecommerce professionals with e-commerce brand operation capabilities.

Secondly, new forms of e-commerce have spawned a batch of entirely new job positions. With the development of the digital economy, innovative e-commerce models such as social e-commerce, live streaming e-commerce, and interest-based e-commerce have emerged successively, giving rise to a new set of industries and job positions. For example, in recent years, numerous platforms like Taobao, JD.com, and Douyin have seen a surge in short videos or live streaming activities used by merchants to promote various products, leading to rapid growth in marketing performance over short periods and thus accelerating the rise of the live streaming industry and the popularity of related live streaming positions. In the third quarter of 2021, the number of job postings in the live streaming industry increased by 11.72% year-on-year, higher than the 6.82% increase in job postings across the entire platform. Meanwhile, the number of job seekers for live streaming positions increased by 46.69% year-on-year, significantly outpacing the growth in job postings.

Lastly, the demand for professionals skilled in data analysis and data application has further increased. The Opinions of the CPC Central Committee and the State Council on Establishing a More Perfect System and Mechanism for the Market-Oriented Allocation of Factor Resources, released on April 9, 2020, clearly states that data has become the most dynamic new factor of production in the digital economy era and a core element and important strategic resource for enterprise production. Compared to traditional retail, the most significant characteristic of e-commerce is that everything can be monitored and improved through data. Data serves as a crucial foundation for corporate decision-making. By analyzing data, e-commerce enterprises can clearly understand consumer behavior, optimize cash flow and inventory, and increase sales. Therefore, data processing capabilities and digital application skills will become important components in the cultivation of applied e-commerce talents.

Considering that digital technology is universally and profoundly transforming the educational landscape, this paper attempts to explore the digital transformation of lifelong learning from the perspective of information ecology theory.

LITERATURE REVIEW

Information ecology theory is an interdisciplinary study of ecology, information science, and system science. It focuses on the mutual influence and interaction between information, people, and their surrounding environment, aiming to promote balanced and coordinated development of the information ecosystem through reasonable management strategies. Its core idea is to draw inspiration from natural ecology and regard information as a resource, achieving rational utilization of information resources by regulating the information

ecosystem composed of people and the information environment. Information ecology theory holds significant methodological significance and practical application value for understanding and optimizing the digital transformation of lifelong learning. At the methodological level, introducing information ecology theory helps to examine digital transformation from an ecological, systematic, and hierarchical perspective, further clarifying and analyzing the relationships and roles of various elements within the educational system, and deeply advancing the digital transformation of lifelong learning. From a practical perspective, analyzing digital transformation using information ecology theory helps to clarify the basic framework of educational digital transformation, propose new and effective solutions, and facilitate the sound development of the digital transformation of lifelong learning.

(1) Conceptual Evolution and Development of Information Ecology Theory

In the 1960s, with the advancement of computer technology, developed countries in Europe and North America began to enter the information society. Scholars conducted research on information from various perspectives, focusing on its many impacts on the economy and society. Based on the depth and perspective of research, the study of information ecology can be broadly divided into three stages.

The first stage is the emergence of information ecology research (from the 1960s to the late 1980s). During this stage, scholars initially proposed the concept of information ecology. Among them, H. Marshall McLuhan, from the perspective of communication studies, was an early advocate of media ecology, believing that electronic media extend the human central nervous system, change people's interaction patterns and social organizational structures, and play a shaping and controlling role in human unity, the scale and form of action. Weinberg GeraldM, from a sociological perspective, conducted indepth research on the impact of information technology on social ethical issues.

The second stage is the deepening of information ecology research (from the 1990s to the end of the 20th century). Rafael Capurro proposed the concept of information ecology and proactively explored issues such as the information gap, information poverty, and information pollution, pointing out that "the production, storage, exchange, dissemination, selection, and use of information have become a critical issue in modern society." Subsequently, Thomas H. Davenport and others introduced ecological ideas into the field of information management, noting that "managers need a holistic perspective that can withstand sudden business transformations and adapt to changing social realities. This new approach is called information ecology, which emphasizes the entire information environment of the organization." Davenport believed that this theory could help address a series of issues related to information culture, information production, information sharing, and information technology. Nardi and O'Day, from a system theory perspective, understood information ecology as an information system composed of people, practices, values, and technologies in a specific environment, with the core being human activities supported by technology, further deepening the understanding of information ecology theory.

The third stage is the diversification of information ecology research (since the 21st century). Foreign scholars consider information ecology as a complex system encompassing multiple elements such as information subjects, technologies, and practical activities. As research continues to deepen, domestic researchers have gradually reached a consensus on the constituent elements of the information ecosystem, namely, "information," "information people," "information technology," and "information environment" as the core elements of information ecology. Among them, information people refer to various entities involved in information production, dissemination, and consumption; information is the sum of information

people's views, attitudes, opinions, and even emotions, serving as the basic element of the information ecology; the information environment refers to the sum of factors that directly or indirectly influence information, usually divided into internal and external environments; and information technology refers to the technologies used for the production, use, and dissemination of information resources.

(2) Construction of an Information Ecosystem Model for the Digital

Transformation of Lifelong Learning Introducing information ecology theory into digital transformation provides a holistic, systematic, and hierarchical perspective for examining the digital transformation of lifelong learning. It helps clarify and analyze the relationships and roles of various elements within the educational system. Based on information ecology theory, the model of an information ecosystem for the digital transformation of lifelong learning is constructed, where elements such as information, information people, information environment, and information technology constitute the entirety of the digital society and serve as the theoretical foundation for the digital transformation of lifelong learning. When mapped into the educational realm, it forms a loosely coupled educational ecosystem composed of educational subjects, educational information, educational technology, and educational environment. In this system, learners leverage advanced digital technology in the digital educational world to facilitate the production, use, dissemination, and exchange of educational resources. Through continuous dynamic adjustment and optimization, educational practice integration is achieved, ultimately aiming at the coexistence of humans and technology and the comprehensive development of learners.

In the information ecosystem model for the digital transformation of lifelong learning, "information people" serve as the ecological core, while "information technology" and "information" as information resources constitute the ecological base, and the "information environment" serves as the ecological repository. The information ecosystem for the digital transformation of lifelong learning is not static but characterized by ecological, systematic, dynamic, contextual, and synergistic features. Elements such as information, people, technology, and environment develop synergistically within the system. Among them, ecologicality refers to the coexistence and complementarity of people, information, technology, and other elements within the digital transformation information ecosystem, forming an ecological system similar to a biological community. Systematicity emphasizes the interdependence and connection of various elements in the educational world, with changes in any element impacting the entire ecosystem. Dynamicity underscores the continuous evolution of the educational ecosystem, requiring educational subjects to view educational change with a dynamic perspective and participate in the transformation of the educational ecosystem with flexible strategies. Contextuality means that changes in the educational ecosystem are more influenced by various elements within the system, with factors outside the system having little impact. Synergy emphasizes the coordinated interaction of various elements within the educational ecosystem to maximize the overall benefits of the system. Information ecology emphasizes the use of a holistic perspective to macro-analyze the elements and their relationships within the system, upon which practical activities are conducted to achieve harmonious development of the information ecosystem.

HOW DIGITAL COMMERCE PROMOTES LIFELONG LEARNING

(1) Cultivating "Informational People": Enhancing Adaptability to Digitalization in Lifelong Learning

Humanity has entered the world of data, and the ability to understand and utilize data effectively has become an essential skill for digital citizens or organizations. Research shows that in 2018, the number of data expert positions in the United States increased fivefold compared to 2014, and the number of machine learning technology engineer positions grew twelvefold. This suggests that digital literacy is becoming a "scarce" skill. Against this backdrop, it is recommended to take multiple measures to help the public enhance their digital literacy. On the one hand, strengthen the cultivation of learners' digital literacy. As more organizations and individuals begin to upgrade and invest in digital-related skills, it is recommended to build a well-structured and mutually recognized learning and training framework, improve the learning outcome certification system, and provide a series of social supports to increase the participation of vulnerable groups, such as those with low skills and low incomes, in learning. On the other hand, adopt flexible and diverse methods to cultivate digital literacy. The emerging information, instructional, and communication technologies, as well as the development and expansion potential of digital tools, require that the cultivation of digital literacy be fluid and organic. Previously, cultivating students to become digital citizens was seen as the "responsibility of schools"; now, it should shift more towards formal and informal learning (including in the family and workplace) to ensure that digital literacy skills are continuously updated. Special emphasis should be placed on strengthening the certification of non-formal and informal learning, which are important pathways for achieving lifelong learning, especially for adult learners. They offer the advantages of flexibility in time and location, can better adapt to the diverse learning methods in the digital age, enhance learners' self-esteem and motivation for continued learning, and bring greater happiness and potential job opportunities to learners.

(2) Enhancing "Information" Quality: Giving New Impetus to Digitalization in Lifelong Learning

Firstly, integrate data to form high-quality structured data resources. The digital transformation of education is based on data, so improving data quality is crucial in the process of educational digital transformation. "Data is the new oil. It is valuable, but if it is not refined, it cannot be truly utilized. It must be turned into natural gas, plastics, chemicals, etc., to create a valuable entity that can drive profitable activities. Therefore, data only demonstrates its value after being analyzed." Educational organizations have accumulated a vast amount of historical data, and their large number of students and business scale ensure the continuous accumulation of new data. Therefore, the dilemma of educational digital transformation is not the lack of data, but rather that the massive amounts of data are not structured and easy to analyze. Currently, school data management remains transactional, with data often being "siloed," such as in teacher management, student management, and teaching resource management, each operating independently. To conduct comprehensive data analysis, it is necessary to merge and integrate data from different departments to form structured data that can be directly used by all departments. Secondly, establish an efficient data analysis ecosystem. Build a data analysis ecosystem composed of leaders, employees, external data analysis providers, partners, and others. As digital technology increasingly infiltrates the educational world, future lifelong learning governance will involve a large amount of data from multiple aspects. Through the

collection, analysis, and processing of data, various educational entities will have greater ability than ever to promptly understand and grasp the internal and external environments of future education and the various states they are in. They will be able to comprehensively analyze and process mixed data from various sources, consider intelligence from multiple aspects, and cross-verify to cancel out errors, thereby greatly enhancing data analysis capabilities. This will help various entities make more scientific and reasonable decisions and further improve the governance effectiveness of lifelong learning.

(3) Reshaping the "Information Environment": Clarifying the Development Directions for Digital Lifelong Learning

Strengthen the construction of new digital infrastructure to enhance the support for digital lifelong learning. Firstly, enhance digital infrastructure construction and optimize the external policy environment. On the one hand, strengthen policy guidance and support. As a cross-cutting industry with significant impacts on the economy and society, "digitization" requires policy as a crucial prerequisite for its comprehensive development. The government, as the most important coordinator and manager in the real world, should integrate multiple resources under policy leadership and coordination to build digitally shared infrastructure for society. This will address the challenges of high costs due to construction by a few entities, which hinder the further popularization of digital resources, as well as educational inequality caused by data resource monopolies by a few large platforms or leading enterprises. On the other hand, strengthen cross-organizational collaboration. Based on policy guidance, integrate fragmented digital facilities into a unified infrastructure system through mutual recognition of facilities, standards, and channels. This will reduce obstacles posed by data silos or isolated data islands to users, save user costs, and improve the effectiveness of digital learning. Secondly, reshape the school organizational environment and build a digital culture conducive to lifelong learning. School education is the initial stage for cultivating students' lifelong learning concepts, abilities, and habits, playing a foundational role. Relevant reports by the United Nations Educational, Scientific and Cultural Organization (UNESCO) also point out that realizing the vision of lifelong learning lies in cultural transformation, especially starting from school education to cultivate a lifelong learning culture. It is recommended that schools actively strive to become data-driven organizations by digitally transforming their business structures, integrating external environmental data with various internal data, seeking partners and establishing continuous cooperative relationships, quickly analyzing environmental changes, audience needs, and feedback for improvement, and gradually building a campus digital culture conducive to lifelong learning.

(4) Strengthening "Technical Ethics": Enhancing the Support for Digital Lifelong Learning

The long-term success of organizations increasingly depends on their ability to leverage digital technology. It can be argued that digital technology is not an isolated technology but rather provides the necessary infrastructure for business innovation. Firstly, promote the integration of digital technology throughout the process of lifelong learning. Digital technology can not only support the digitization and intellectualization of teaching but also change other business areas of schools, such as recruitment, daily management, and relationships with stakeholders like industries and enterprises. Furthermore, digital transformation does not merely refer to using digital technology to support business processes but rather to using it to transform the core business of schools to adapt to the demands of the digital era. To succeed in

the digital transformation process, schools must become flexible and agile, quickly perceiving, identifying, understanding, learning, and adopting new digital technologies to promote various learning activities. Secondly, enhance the ability to analyze and integrate educational data. Due to limitations in data collection, processing, and analysis capabilities, traditional organizations can often only handle partially structured data in a certain field and frequently need to sample and analyze this data to make decisions. The scientificity and accuracy of traditional educational governance decisions based on partially structured data using probabilistic statistical analysis and other methods are often difficult to guarantee. With the development of digital technology, data-driven organizations can more easily use new technologies and means to collect, process, and analyze full samples of all relevant structured and unstructured data for future educational governance. This allows for comprehensive consideration of the internal and external environments of future education, a more comprehensive understanding and grasp of the challenges faced by future educational governance, and accordingly, more accurate and scientific governance decisions, enhancing the scientificity and effectiveness of future educational governance.

CONCLUSION

After more than 20 years of development, e-commerce has become increasingly sophisticated and stands as a pivotal force in promoting entrepreneurship, stabilizing employment, deepening international trade, and facilitating rural poverty alleviation and revitalization in China. It also serves as a new driving force for the transformation and upgrading of traditional industries and the development of the digital economy. Colleges and universities should keep abreast of the times, optimize their internal education innovation mechanisms, enhance their capacity for reform in digital economy education, and further promote the cultivation of high-level, interdisciplinary, and applied ecommerce talents in the context of the digital economy. This endeavor will contribute to the realization of the great rejuvenation of the Chinese nation.

REFERENCES

Yu Shengquan. (2023). The Hierarchy of Digital Transformation in Education. China Electronic Education, (2). https://doi.org/10.3969/j.issn.1006-9860.2023.02.008

Shu Hang, Gu Xiaoqing. (2023). Digital Transformation of Education in the Era of Digital Intelligence: From the Perspectives of Social Change and Organizational Reform. Journal of Distance Education, 41(2). https://doi.org/10.15881/j.cnki.cn33-1304/g4.2023.02.003

Li Ning, Xu Zhimin. (2023). From Vision to Reality: Lifelong Learning Policies, Implementation Strategies, and the Construction of Learning Cities - An Analysis of the UIL Handbook "Making Lifelong Learning a Reality". Adult Education, 43(9). https://doi.org/10.3969/j.issn.1001-8794.2023.09.002

Lv Jianqiang. (2023). Employability: An Important Growth Point in Higher Vocational Education Research. Vocational Education Forum, 39(7):17-25.

Yu Guoming, Li Fan. (2023). Relationships, Information, and Fields: A Discussion on Future Communication Modes Amid Enhanced Irrational Factors. Journal of Journalism and Communication, 76(3):5-16. https://doi.org/10.14086/j.cnki.xwycbpl.2023.03.001

Yang Yujiao, Yuan Qinjian. (2022). Information Ecology Theory and Its Application Prospects in the Field of Information Systems Research. Modern Information,42(5):9. https://doi.org/10.3969/j.issn.1008-0821.2022.05.014.

Li Xingzhou, Fan Fan. (2022). The Postmodern Implications of Adult Lifelong Learning. Vocational Education Forum, 38(8):7.

Ma Tingqi, Li Rongfang. (2021). The Transformation of Knowledge Production Modes and the Innovation of Talent Cultivation Modes. Higher Education Development and Evaluation, (3):61-66. https://doi.org/10.3963/j.issn.1672-8742.2019.05.002

Shi Lanyue. The Transformation of School Education's Status and Mission Under the Concept of Lifelong Education. Journal of Henan Normal University (Philosophy and Social Sciences Edition), 2010, (3):2. https://doi.org/CNKI:SUN:HNSK.0.2010-03-067

Yu Shengquan, Zhao Xinglong. (2009). Advancing Regional Education Informatization Based on the Perspective of Information Ecology. China Electronic Education, (8):8. DOI: https://doi.org/10.3969/j.issn.1006-9860.2009.08.007

Ge Daokai. (2023). Challenges and Responses to the Development of Higher Education in the Post-Pandemic Era. China Higher Education Research, (2). https://doi.org/10.16298/j.cnki.1004-3667.2023.02.05

Huang Xinrong, (2022). Cao Xianping. The Technical Essence and Philosophical Significance of the Metaverse. Journal of Xinjiang Normal University (Philosophy and Social Sciences Edition), 43(3).

Li Longfei, Zhang Guoliang. (2022). The Formation Mechanism and Governance Path of the "Information Cocoon" Effect in the Algorithm Era - Based on the Perspective of Information Ecology Theory. E-Government, (9):51-62. https://doi.org/10.16582/j.cnki.dzzw.2022.09.005

Thomas Siebel (translated by Bi Chongyi). Understanding Digital Transformation [M]. China Machine Press, 2021.

Raz Hefidmen (translated by Xi Yishan). Digital Leapfrogging: Strategies and Tactics for Digital Transformation [M]. China Machine Press, 2020.

Ulrich Beck. Risk Society: Towards a New Modernity [M]. Yilin Press, 2018.

Robert Hutchins. The Learning Society [M]. Social Sciences Academic Press, 2017.

Anthony Smith. The Postmodern University Coming? [M]. Peking University Press, 2014.

Michael Gibbons, et al. (translated by Chen Hongjie, Shen Wenqin, et al.). New Modes of Knowledge Production: Dynamics of Contemporary Social Science and Research [M]. Peking University Press, 2011.

THE ECONOMIC IMPACT OF WATER VULNERABILITY TO CORPORATE SUSTAINABILITY: A PERSPECTIVE OF CORPORATE CAPITAL COST

Gao Pengqun[A], Zheng Liyuan[B], Li Ling[C], Tao Bianshiyu[D], Lai Huaqiang[E]

ABSTRACT

Studies argued that water risk affects corporate sustainability, but few of them have fully explored whether and how water resources have a direct impact on corporate finance and strategy. This study takes the listed companies in China A share from 2019 to 2023 as a sample to understand the threat of water vulnerability to corporate sustainability from the perspective of capital cost. This study argues that water vulnerability positively relates to corporate capital cost by increasing corporate financing constraints. Meanwhile, this study also examines the role of water regulation and water investment in the relationship between water vulnerability and corporate capital cost. Water regulation brings legitimate pressure to corporates and increases the transformation risks faced by them, so it has a positive moderating effect. Water investment can alleviate the vulnerability of local water resources and reduce the physical water risk faced by corporates, so it has a negative moderating effect. The study finds that the two measures mainly play a significant moderating effect on the cost of debt. In addition, the study finds that the positive relationship between water vulnerability and capital cost has industrial and firm-level heterogeneity, while the moderating effect of government water governance has only industrial heterogeneity.

Keywords: *Water vulnerability, Capital cost, Cost of debts, Water-intensive industry*

1. INTRODUCTION

Water sustainability is central to several of the United Nations' sustainable development objectives. Global demand for clean water is expected to exceed 40% of the available supply by 2030, but the quality and quantity of freshwater have declined significantly over the last few decades due to global population growth and climate change (CEO Water Mandate, 2008) [1]. The global water crisis has become the world's third-biggest threat and one of the main risks that the business sector needs to address (World Economic Forum, 2017) [2].

Studies have shown that businesses face serious physical, reputational, and regulatory water risks all at once (Jones et al., 2015; Tello, 2013) [3,4], which already have significant implications for business development when companies internalize these risks (Zhu et al., 2024;

[A] *Doctor of Management (Ph.D.), Business School, Jiangsu Open University, Jiangsu Province, China. Email: gaopq@jsou.edu.cn*
[B] *Doctor of Management (Ph.D.), Business School, Hohai University, Jiangsu Province, China.*
[C] *Master of Arts, Headmaster's Office, Jiangsu Open University, Jiangsu Province, China.*
[D] *Master of Business Administration (M.B.A.), Business School, Jiangsu Open University, Jiangsu Province, China.*
[E] *Master of Economics, Business School, Jiangsu Open University, Jiangsu Province, China.*

Afrin et al., 2022; Liu et al., 2024) [5-7]. However, most academics only focus on reputational and regulatory water risks by studying the effects of social factors like institutions and stakeholders under socio-centric theories and fail to consider the direct impact of physical water risks on corporate sustainability (Dias et al., 2022; George et al., 2015; Tashman, 2021; Tashman & Rivera, 2016) [8-11]. Water vulnerability is a measure of the state of a water resource system that is subject to shocks from human activity and natural change, and the degree to which it is difficult to restore to its original state after a shock (Xia J. et al., 2012) [12], and is also used as a measure of physical water risk (Zheng et al., 2022; Gui et al., 2021) [13,14]. Thus, what exactly is the impact of water vulnerability on businesses? How does this impact arise? How business could adapt to these risks? These questions are still being addressed at the 'should be' level, with little empirical research at the 'real be' level (Burritt et al., 2016; Ortas et al., 2019; Sojamo & Rudebeck, 2024) [15-17].

Water governance by the government is seen as a crucial means of resolving water issues to avoid the tragedy of the Commons. However, majority studies to far have concentrated on the regulatory tools while ignoring the varying effects of other governance mechanisms (Li & Yuan, 2021; Ban & Liu, 2021; Ma & Hou, 2020) [18-20]. Research solely from the standpoint of environmental regulation misses the mark in capturing the impact of government environmental governance, fails to account for the possibility of crowding out or multiplier effects between different instruments, and often leads to governments adopting more stringent regulatory tools. While strict environmental regulations help achieve regulatory goals, they may have unintended consequences for businesses' output and operations if the burden becomes too great (Cui & Jiang, 2019) [21], which would prevent companies from effectively adapting to the external institutional environment in the context of sustainable development and results in a lack of effective micro-level pathways to the sustainability of water resources.

This paper is therefore concerned with three main questions. The first question is whether water vulnerability has become an external risk that firms cannot ignore? Considering the capital market, do investors react to water vulnerability to demand a risk premium? The second question is, what is the impact of government water governance tools in the relationship between water vulnerability and corporate capital costs? The third question is whether these impacts are heterogenous to different kinds of firms? These interesting questions prompted further research to examine the relationship between water vulnerability and the cost of capital, including moderating effects of government water governance (which are divided into water regulation and water investment). We find that water vulnerability increases the cost of debt, and water regulation intensifies while water investment reduces the impact. Water vulnerability increases the cost of equity, but both regulation and investment have no significant influence on the relationship between water vulnerability and the cost of equity.

The contributions of this work may be broken down into three categories. To begin, different environmental problems have diverse effects on businesses. Even though most prior research has concentrated on the effects of climate change and air quality, we focus on water resources, which contributes to the growing body of literature on the influence that natural resources and the environment have on businesses. Second, most of the prior research on water vulnerability has been on determining how it should be measured and how it should relate to economic growth; however, very few studies have looked at the micro-level implications of water vulnerability. We contribute to the growing body of research on water management by focusing on the influence that water vulnerability has on the corporate capital costs. Thirdly, past research has ignored the importance of government investment in environmental problems in favor of concentrating on regulation. Wey further classifies environmental governance implemented by the government into two distinct categories of tools: regulation and investment. By doing so, the study verifies that various tools utilized by the government for environmental

governance have distinct effects and adds to the existing body of knowledge concerning environmental governance.

2. LITERATURE REVIEW

2.1 The socio-economic impact of water vulnerability

Current research on water vulnerability mainly focuses on the evaluation and the causes of water vulnerability, but some studies have expanded to areas such as adaptive management of water resources, water resource policies evaluation, and the socio-economic impact of water vulnerability (Yuan & Zheng, 2022) [22]. In the study of the socio-economic impact of water vulnerability, Jenkins etc. (2021) calculated that water vulnerability could bring £ 1.4 billion direct economic loss to United Kindom [23]. Other related economic loss calculated by researchers contains the loss of human life and medical costs caused by water pollution (Ugochukwu etc., 2022) [24], as well as productivity losses caused by water scarcity and water disasters (Temkin etc., 2019) [25]. Furthermore, Gleick (2014) discovered that water vulnerability affects economic development and then brings social instability in Syria [26]. Schilling et al. (2020) also confirmed that social conflicts arose with the deterioration of water conditions because public's water needs cannot be met under water vulnerability [27]. Based on the above, some scholars further presented that water vulnerability becomes a physical risk that affects business sustainability (eg. Bonnafous et al., 2017; Muthulingam et al., 2022; Northey et al., 2019) [28-30]. Zheng. et al. (2022) proved that water vulnerability has a significantly direct negative influence on ROA of enterprises [13]. Liu et al. (2024) opined that water risk affects operational and financial uncertainty and corporate legitimacy [7].

2.2 Environmental Factors Affecting Corporate Capital Costs

The factors affecting corporate capital costs can be categorized into technological factors, organizational factors, and environmental factors. Technological factors refer to the methods and assumptions used to estimate corporate capital costs (Jagannathan et al., 2017) [31], and new technologies used to alleviate corporate financial constrains such as fintech (Lyu et al., 2023) [32]. Organizational factors refer to accounting factors such as profitability and capital structure (Jagannathan et al., 2017) [31], as well as factors such as corporate governance and strategy (Benlemlih, 2017) [33]. Environmental factors contain market related, institutional related and biophysical related factors (e.g. Sassi et al., 2019; Li et al., 2024; Daouk et al., 2006) [34-36]. Among these three types of factors, despite organizational factors are the most concerned by scholars, environmental factors also have relatively high attentions.

In the studies of environmental factors, Sassi et al. (2019) found that intensified product market competition results in lower equity financing costs [34], and Amairi et al. (2022) revisited the relationship between market competition and equity financing to be a U shape [37]. Apart from market competition, Hillier & Loncan (2019) and Li et al. (2024) respectively verified that stock market integration and stock market liberalization could reduce financing costs [38,35], and Vega- Gutierrez et al. (2021) found labour market conditions is also another important factor [39]. Among institutional related factors, economic policy uncertainty (Xie & Lin, 2023) [40], government macroeconomic management tools such as monetary policy, tax and security laws (Sheng et al., 2017; Lendvai et al., 2013; Daouk et al., 2006) [41,42,36], customer satisfaction (Truong et al., 2021) have also been testified to be the influencing factors [43].

With the increasing attention from accounting and management academia on the deterioration of the natural environment, the relationship between biophysical environment and corporate capital costs also begins to grow, but it is still at initial stage. At present, scholars mainly explore the impact of climate change on capital costs. Kling et al. (2021), Huang et al. (2018), Yildiz & Temiz (2024) verified that climate change does harm to corporate financing [44-46], while the study from Du et al. (2023) denied the significant relationship between climate change and the cost of equity. Other biophysical environments receive scattered attentions [47]. Liu (2016) and Tan et al. (2022) found that the cost of debts increases with the deterioration of air pollution [48,49]. As far as we know, only Nguyen et al. (2022) found that drought has negative effects on both leverage and the speed of leverage adjustment to enterprises [50], offering undirected evidence to the relationships between water conditions and the cost of capital.

2.3 Government Water Governance

In session 2.1, we briefly review the negative socio-economic impact of water vulnerability. To mitigate these negative impacts, researchers propose adaptive water resource management strategies. Although some public management studies do not encourage top-down authoritative water regulation as they believe that mandatory and centralized water management policies may lead to conflicts between private actors (Heikkila, 2017; Harley et al., 2014) [51,52]. However, many countries, such as China and Israel, still believe that the government is the most important governing body in addressing water resource issues.

Government usually adopts various policy tools for water resource adaptive management. Firstly, government adopts commend-and-controls measures to strongly constrain the behavior of various subjects to improve water conditions. For example, government directly allocates the amount of available water resources through administrative means such as water intake permits (Li, et al., 2019) [53], and implements the Water Pollution Prevention and Control Action Plan to directly constrain industrial pollution discharge (Lu et al., 2022) [54]. In addition, government also adopts market- incentives mechanisms such as water rights and discharge right, water pricing and water tax, ecological compensation, and so on, which can induce the economic interests of water users to achieve the goals of alleviating water scarcity and restoring the water ecological environment from a micro perspective. These regulation tools have been widely proven to alleviate water resource scarcity and degradation, promote industrial structure adjustment and economic development, and enhance green transformation of enterprises (Li et al., 2019; Lin, XC., et al., 2022; Luckmann et al., 2016; Zhou et al., 2021) [53,55-57].

Apart from regulation, government will adopt various infrastructure investments to alleviate the scarcity problem of uneven spatial and temporal distribution of water resources, repair damaged water ecological environments, and increase the region's ability to respond to water and drought disasters (Li, et al., 2020; Adeniran et al., 2021) [58,59]. For example, the Chinese government's investment in the construction of the South to North Water Diversion Project has alleviated the water resource problems in the Beijing Tianjin Hebei region (Long, et al., 2020) [60]. Meehan (2014) also presented that the advantages of these investment in water infrastructure are far from restore water conditions but also could maintain social stability and consolidate political power in return [61].

2.4 Review

This literature review above shows that extensive research on water vulnerability, corporate capital costs, and government water governance has produced valuable results. However, research gaps and opportunities remain. Firstly, although the socio-economic impact of water

vulnerability has received some attentions, those focuses are mainly on the macro impact and lack micro verifications such as the impact on organizations (Baudoin & Arenas, 2020; Zhu et al., 2024) [62,5] especially the impact on the cost of capital. For the study of the cost of capital, the biophysical impact is one of the cutting-edge topics in the current cross research of financial management and natural science. Kling et al. (2021) and Huang et al. (2018) have made relevant explorations, but there is still an urgent need for more empirical research to further clarify the specific relationship between the two, especially under different natural environments including water issues [44,45]. Secondly, government water governance is regarded as the main means of water resources adaptive management, and both social scientists and natural scientists have studied it. Among them, natural scientists start from the perspective of water infrastructure investment and construction to verify its macro impact to ecology, society and economic growth (Yang et al., 2024) [63], and overlook the impact of such measures on micro-entities such as enterprises (Li & Yuan, 2021; Ban & Liu, 2021; Ma & Hou, 2020) [18-20]. The social scientists typically focus on the direct constraints of institutions on social actors, seldom paying attention to how their interaction with the natural environment will affect social actors such as businesses (Tashman, 2016) [11]. Thus, the impact of water vulnerability and its interaction with government water governance measures to corporate capital costs requires further study.

3. HYPOTHESIS

3.1 The impact of water vulnerability on corporate capital cost

Water vulnerability is expressed as an imbalance between the supply and demand of water resources within a region over a certain time (Xia et al.,2012) [12]. Availability of local water resources is reflected in both governmental administrative permissions and water company deliveries (Northey et al., 2019) [30], for the only legal means for businesses to receive water are through water supply corporations or by obtaining abstraction licenses. When water supplies are limited, people and businesses in the region may face difficulties such as drought. Businesses may have water interruptions or have their water supply insufficient for everyday operations if fundamental social requirements take precedence over commercial production demands (Appiah & Abass, 2014; Hazelton, 2013) [64,65]. The danger of water shortage can extend across a firm's supply chain even if water is plentiful in the region in which the company works (Vos & Hinojosa, 2016) [66]. But when water supplies decrease, companies face rising water costs due to increased water price, water rights fees, water taxes, etc (Martinez, 2015; Fogel & Elizabeth, 2014) [67,68].

Second, water vulnerability indicates the decrease in the quality of water environment (Xia et al.,2012) [12]. Water quality could exacerbate reginal water shortage, thus increase expense associated with using water from the public network since businesses must purify water resources before using them, among other factors (Fogel & Elizabeth Palmer, 2014) [68]. A decline in water quality indicates a broader decline in the quality of life in the region, and this can have far-reaching consequences for businesses by limiting their access to funding and talent (Ugochukwu et al., 2022; Wang et al., 2023) [24,69]. The decrease of water quality also makes a higher probability of cause the local government and community to question the legitimacy of enterprises (Northey et al., 2019; Christ, 2014) [30,70].

Third, water vulnerability shows up when the amount of water available in the region shifts in time and location because of shifts in precipitation patterns brought on by climate change and a rise in the frequency of extreme weather events (Gui et al., 2021; Sun & Kato, 2021) [14,71]. Droughts, floods, and other natural calamities are all examples of the unpredictable

physical hazards that can threaten corporate operations (Bonnafous et al., 2017; Jiao et al., 2022) [28,72]. Droughts, for instance, may make water shortages an even bigger issue for businesses, while floods can halt operations and lead to lost equipment (Song et al., 2019) [73].

To sum up, water vulnerability squeezes out human capital, disrupts the stability of enterprise supply and production, reduces labor productivity, and increases operating costs, thus posing a business threat to corporate sustainability. Zheng et al., (2022) also confirm that a company's financial performance is negatively impacted by its susceptibility to water [13]. According to the risk compensation theory, the cost of capital for a company is the premium that investors want in exchange for bearing some degree of uncertainty. A company's total cost of capital may be broken down into the cost of debt and the cost of equity. The cost of debt is the sum of the nominal risk- free rate and the risk premium, and the cost of equity capital is a function of risk based on the asset pricing model. Thus, water vulnerability increases the business risk of a firm and therefore exposes investors to higher credit risk. This paper is predicated on the following hypothesis:

Hypothesis 1a: The higher the water vulnerability, the higher the cost of debt.
Hypothesis 1b: The higher the water vulnerability, the higher the cost of equity.

3.2 The moderating effect of government water governance

To deal with the effects of climate change and human activities on the geographical and temporal distribution of water resources, adaptive management of water resources is required, as stated by Xia, Qiu & Li (2012) [12]. To avoid the tragedy of the commons brought on by 'free riding' behavior from multiple users, government action is considered as a crucial means of ensuring that public commodities are allocated effectively for societal wellbeing (Qin, Harrieon & Chen, 2019) [74]. Regulatory instruments, such as law and enforcement, and investment in engineering and ecological restoration, are the primary tools governments use when intervening (Li, 2017) [75]. The processes and effects of various policy tools on water governance vary; nonetheless, most studies have concentrated on regulatory instruments, whereas the influence of public investment has received comparatively little attention (Li & Yuan, 2021; Ban & Liu, 2021; Ma & Hou, 2020) [18-20].

Governments frequently use environmentally related rules as a means of coercion towards enterprises, such as license to operate, hefty fines and fees. Companies feel increased pressure to retain environmental legitimacy as the need for stricter environmental regulation grows louder. For water, this is conveyed as a demand for responsible water conservation and management on the part of businesses (Jones et al.,2015; Egan, 2015; Lambooy, 2011) [3,76,77]. Companies that must comply with new water regulations may feel the need to make significant changes. And environmental regulation shifts resources away from the production sector and into the pollution sector, increasing businesses' marginal costs (Greenstone et al., 2012) [78]. As a result, business performance will suffer loss in the short run (Zheng et al., 2022, Long & Wan, 2017) [13,79]. Meanwhile, to increase water efficiency and decrease effluent emissions, process transformation and technical improvements are required for enterprises. According to Porter, businesses may gain a competitive advantage through technical innovation. However, green innovations carry with them a degree of uncertainty and danger, and technology advancements don't always make businesses safer in the near term (Yan et al., 2021) [80].

Because water regulation may intensify the impact of water vulnerability on firms, investors may demand a higher risk premium. We predict that:

Hypothesis 2a: Government water regulation positively moderates the relationship between water vulnerability and the cost of debts.
Hypothesis 2b: Government water regulation positively moderates the relationship between water vulnerability and the cost of equity.

The government will alter the geographical and temporal distribution of water resources in terms of quantity and quality by improving water infrastructure and impleting water ecosystem restoration, in addition to enforcing stricter environmental regulations (Petts & Gurnell, 2022) [81]. First, the availability of water in a region can be improved by infrastructure investments like reservoirs and water diversion projects. For instance, the Chinese government's construction of the South-North Water Transfer Project has altered the regional distribution of water resources and enhanced the adaptive capacity of water-scarce areas (Qu et al., 2020) [82]. Second, degradation of the natural environment influences both labor costs and productivity, as was discussed before. Thus, environmental improvements reduce labor costs and help improve business efficiency. Third, a region's ability to withstand floods and droughts can be strengthened by the construction of reservoirs and dikes, which in turn reduces the likelihood that output losses will occur because of flooding. Even though companies may have to pay more for water because of these storage and supply initiatives, the price of water does not completely represent its scarcity value due to human rights of water resources, and therefore water prices remain low generally (Egan, 2015; Martinez, 2015) [76,67].

Because that water investment may relieve the negative impact of water vulnerability on firm, investors may demand a lower risk premium. We predict that:

Hypothesis 3a: Government water investment negatively moderates the relationship between water vulnerability and the cost of debt.
Hypothesis 3b: Government water investment negatively moderates the relationship between water vulnerability and the cost of equity.

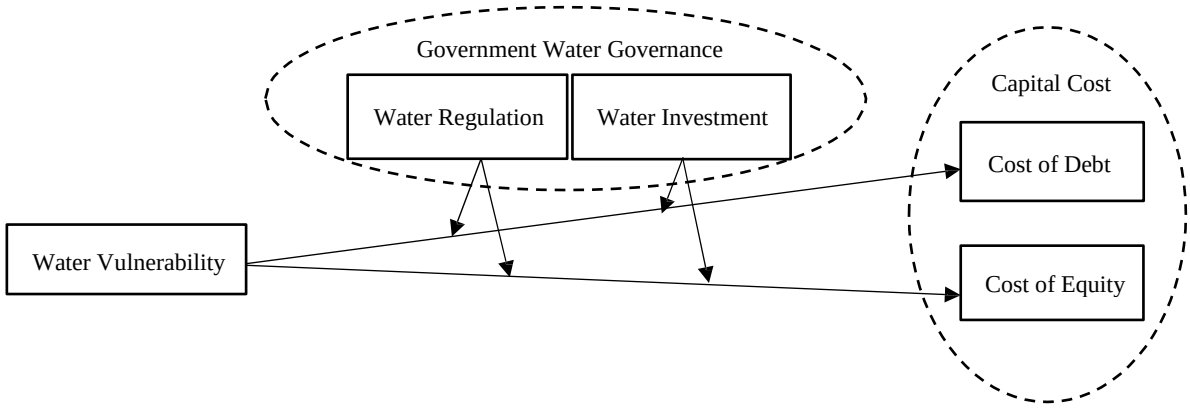


Figure 1 – Conceptual Model

4. STUDY DESIGN AND DATA DESCRIPTION

4.1 Sampling

This paper use data from 30 Chinese provinces and municipalities (excluding Tibet and Hong Kong, Macao, and Taiwan) over the course of five years (2019-2023). The reason to

exclude Hong Kong, Macao, and Taiwan is that they have a high degree of autonomy, demonstrating obvious difference in political system to mainland China. The exclusion of Tibet owes to missing data.

Companies in the financial sector are not included in this study since their investment and financing practices differ greatly from those of the rest of the economy. Because enterprises on delisting alert have very different risk characteristics than non-delisting alert firms, the cost of capital for the former is not included in the sample. After eliminating those with missing data, the article gets a total of 12,361 samples.

The data sources for this paper are as follows: financial data from CSMAR databases; water vulnerability data and government water investment data from China Statistical Yearbook, China Water Resources Statistical Yearbook, China Water Resources Bulletin and China Urban and Rural Construction Statistical Yearbook; government water regulation data from provincial government work reports. Stata 17.0 was used for the data processing.

4.2 Construction of Variables

4.2.1 Water Vulnerability

Water vulnerability is a measure of the state of a water resource system that is subject to shocks from human activity and natural change, and the degree to which it is difficult to restore to its original state after a shock (Xia J. et al., 2012) [12]. According to Gui, Chen & He (2021), water vulnerability can be divided into four aspects: sensitivity, exposure, hazard, and adaptivity [14]. Sensitivity reflects the degree of dynamic change of water resources. Exposure reflects the dependence of economic and social development on water resources. Hazard reflects the severity of economic and social impact brought by the temporal and spatial changes of water resources. Adaptability indicates the extent to which social and economic development has managed water resources.

The measurement of water vulnerability has several ways. Indicator systems, single indices, and model analyses are all seen in present water vulnerability assessment. Indicator systems is the mainly method used by research to assess water vulnerability. Studies have attempted to establish a system of indicators based on some integrated framework such as IPCC framework, the VSD, and the Drive-Pressure-State-Impact-Response (DPSIR) that corporate several attributes such as adaptability, hazard risk, ecology and environment for evaluating water vulnerability. This paper follows research by Gui, Chen & He (2021) that examines the assess water vulnerability from four aspects—exposure, sensitivity, hazard risk, and adapativity [14]. Indicators of the relevant dimensions were referred to studies by Gui, Chen & He (2021), Liu & Chen (2016), and Su et al. (2018) [14,83,84]. The entropy approach was applied to conduct a comprehensive assessment. The specific indicators are shown in Table 1.

4.2.2 Capital Cost

Capital cost is mainly divided into the cost of debt and the cost of equity. There are currently two main types of measures of the cost of debt: one is to use the interest rate on bank borrowings as a proxy variable; the other is to use the current year's interest as a proportion of the firm's current year liabilities as a proxy variable. This paper argues that bank borrowing is only one source of debt funding. The interest rate level of bank funds is lower compared to other funds, and the threshold set by banks for borrowers is higher. This paper, therefore, argues that bank borrowing rates do not fully reflect the cost of debt. Drawing on Zou et al (2003), the cost of debt = (interest expense + capitalized interest) / average interest-bearing debt for the year [85].

There are many ways to calculate the cost of equity, mainly divided into ex-ante and ex-post models. The ex-ante model, such as the PEG model, is superior to the ex-post model, such as the CAMP model (Mao et al., 2012) [86]. However, due to the late start of intermediary services such as analyst forecasting in China, analyst forecasting data are only available for a small sample of companies. Meanwhile, the applicability of the CAMP model to calculate the cost of equity of firms is limited in developing countries (Kling et al., 2021) [45]. Thus, this paper follows Lin, Zheng & Bo (2015), Zhou et al. (2018a; 2018b) and others to use the inverse of the P/E ratio as a measure of the cost of equity [86-88].

Table 1 – The measurement of water vulnerability

Water Vulnerability	Sensitivity	Absolute value of annual precipitation variation
		Absolute value of annual total water resources variation
	Exposure	GDP per capita
		Share of GDP in primary production
		Water resources per capita
		Total water resources / total area of the region
		Total water resources / total annual rainfall
		Proportion of high-quality surface water
		Ratio of water resources supply to demand
		Proportion of groundwater supply
		Water consumption of 10,000 Yuan of GDP
		Water consumption of 10,000 yuan of industrial value added
		Water consumption by urban residents for domestic use
		Water consumption for agricultural irrigation
	Hazard	Regional population affected/ National population affected in the year
		Regional direct economic losses/ National losses in the year
		Area of crops affected in the region / National damage in the year
		Population with drinking water difficulties in the region / National population affected in the year
	Adaptivity	Wastewater treatment rate
		Water reuse rate
		Ratio of protected arable land
		Protection of population ratio
		Effective utilization rate of irrigation water

4.2.3 Water Governance

In this study, we separate the functions of government water governance into regulation and investment. There are currently two ways to quantify water regulation: the first is to examine industrial emissions related to water resources as a proxy variable, and the second is to examine the frequency and weight of water resources-related terms appearing in government work reports as a reflection of the government's regulatory pressure (Chen & Chen, 2018; Chen et al., 2018) [89,90]. This paper argue that the government's work report is a programmatic document that serves as an outline for the administration and implementation of the authority's decisions and resolutions in accordance with the law. Therefore, the frequency of occurrence of water-related terms in the government work report and their proportion are a more comprehensive representation of the strength of government water regulation.

In this paper, the following steps were taken to construct the water resources regulation indicators: firstly, the government work reports of 30 provinces from 2016 to 2020 were

collected by hand; secondly, the government work reports were word-sorted; finally, the frequency of water resources-related words was counted and their proportion of the total number of words in the government work reports was calculated. The specific words related to water resources include water environment, water resources, water pollution, water safety, water ecology, river and lake, river (lake) chiefs, water price, water use and water quality.

According to the China Water Statistics Yearbook, the main uses of government investment in water resources include flood control, irrigation, drainage, water supply, hydropower, soil conservation and ecological restoration, institutional capacity building, early-stage work and others. We use the sum of investment completed this year after excluding hydropower and institutional capacity building as the preliminary measurement of water investment, because investing in hydropower is done primarily to solve energy problems, while strengthening institutions helps run the government. To eliminate the influence of provincial economic development on water investment and increase the comparability of water investment among different province, we take the ratio of the sum of water investment to local GDP as the final measurement of water investment.

4.2.4 Control Variables

Regarding previous relevant studies examining the cost of capital and the impact of natural resources and the environment on firms (Kling et al., 2021; Huang et al., 2018; Zhou et al., 2018a,b,) [44,45,87,88], this paper controls for firm financial performance (ROA), market-to-net ratio (BM), firm size (SIZE), asset-liability ratio (LEV), stock liquidity ratio (Turnover), and equity concentration (SHR) at the firm level. The regional level controls for total regional GDP (LGDP), and regional GDP growth rate (GGROWTH).

4.3 Model and Estimate Method

In accordance with recent research results (Zheng et al., 2022; Kling et al., 2021) [13,44], we used the following equation to study and test the hypotheses:

$$\text{Capital} = \beta_0 + \beta_1 Water_{Vul} + \sum_i \beta_i Controls_i + \sum_j \beta_j Industrialfixed_j + \sum_l \beta_l Yearfixed_l + \varepsilon_{it} \quad (1)$$

To further test the moderating effect of water governance, the interaction term between water governance and water vulnerability is introduced in Eq. (1). The equation is as follows:

$$Capital = \beta_0 + \beta_1 Water_{Vul} + \beta_2 Water_{Gov} + \beta_3 Water_{Vul} * Water_{Gov} + \sum_i \beta_i Controls_i + \sum_j \beta_j Industrialfixed_j + \sum_l \beta_l Yearfixed_l + \varepsilon_{it} \quad (2)$$

In the above equations, *Capital* respectively represents the cost of debt(r_debt) and the cost of equity(r_equity), $WaterVul$ represents water vulnerability, $Water_{Gov}$ respectively represents water investment (Water_Inv) and water regulation (Water_Ins). In addition, the Hausman test indicates that the fixed effects model should be adopted in this paper.

5. EMPIRICAL ANALYSIS

5.1 Main Analysis

Firstly, this paper presents a descriptive analysis of water vulnerability by region and by the province in China. The vulnerability of water resources by region is shown in Table 2 and

by the province in Figure 2. The results of the descriptive statistics are generally consistent with other studies of China's water vulnerability. Firstly, the level of water vulnerability in all regions of China is moderate and shows a decreasing trend, indicating that China has made significant progress in water resources management and has further improved its ability to ensure water security. Secondly, there are still significant regional differences in water vulnerability across China. The vulnerability of water resources is significantly higher in the north than in the south, which is consistent with the spatial and temporal distribution of water resources in China. Particularly, water vulnerability is highest in northern China, due to the scarcity of total water resources in northern China but the high- water demand of society. North China faces water resources and water environment problems such as groundwater over-exploitation and water quality deterioration (Sun & Kato, 2021) [71]. Southwest China has the lowest water vulnerability, probably because it is the 'water tower' of China, with abundant water resources and a sparse population.

In terms of water vulnerability by province, Ningxia has the relatively highest vulnerability. Not only is Ningxia experiencing severe water shortages due to drought, but it also faces frequent natural disasters and a high spatial concentration of human activities (Han et al., 2020) [92]. Followed by Ningxia, Heilongjiang Province has relatively high-water vulnerability, probably due to the high seasonal fluctuations in water resources, the limited water production capacity and the rapid growth in water demand from socio-economic development (Qiu et al., 2008) [93]. Provinces such as Shanghai, Beijing and Tianjin are not only under pressure from the mismatch between local water supply and demand but also face water pollution problems (Cao et al., 2019) [94]. These provinces, therefore, have a higher water vulnerability. Provinces such as Guangdong, Guangxi, Zhejiang and Jiangxi have lower water vulnerability due to their more abundant water resources and better water environment quality. In conclusion, the spatial distribution of water resources vulnerability is generally consistent with previous studies.

Table 2 – Descriptive statistics of water vulnerability

Region	2019	2020	2021	2022	2023	Mean
North China	0.3428	0.3380	0.2932	0.3306	0.2781	0.3165
Northeast China	0.3188	0.3196	0.3120	0.2747	0.2728	0.2996
Northwest China	0.3323	0.3115	0.3098	0.2951	0.2736	0.3045
Eastern China	0.2315	0.1947	0.1894	0.1864	0.1794	0.1963
South-Central-China	0.1916	0.1834	0.1765	0.1622	0.1587	0.1745
Southwest China	0.1432	0.1395	0.1311	0.1298	0.1189	0.1325

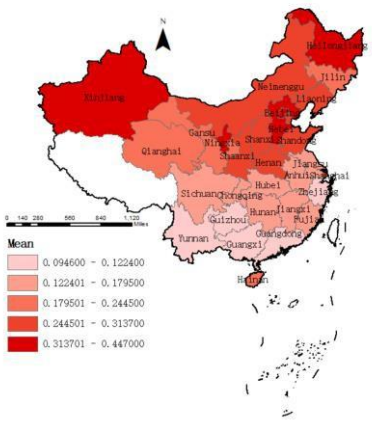


Figure 2 – The mean level of water vulnerability of each province

To provide a more detailed analysis of how water vulnerability affects the cost of capital, the main variables are analysed descriptively, as shown in Table 3. In terms of capital cost, although the overall mean is not high, the difference between the very high and very low values is large, suggesting that some companies still have difficulties in raising finance and that the cost of financing is high, which is not conducive to long-term future growth. Water vulnerability ranges from a maximum of 0.3918 to a minimum of 0.046, with a mean value of 0.1924, suggesting that China's overall water vulnerability is moderate, with significant spatial variation. On the one hand, this result indicates that the Chinese government has made outstanding achievements in water governance, but on the other hand, it also suggests that companies may not be aware of water risks or underestimate the impact that water vulnerability may have. Other control variables are also considered in this paper and the values are very similar to previous studies and are not explained here.

The Pearson correlation test (lower triangle) and the Spearman correlation test (upper triangle) were used to identifying the presence of multicollinearity in the model and the results of the correlation coefficient calculations are presented in Table 4. The results show that the cost of debt is significantly correlated with water vulnerability. This provides some indication that firms are exposed to water risk, providing partial evidence for H1. The current non-significant negative relationship between water vulnerability and the cost of equity capital suggests that there may be a more complex relationship between the two, which needs to be further investigated. The correlation between government water governance and capital cost and water vulnerability provides some support for H2. The correlation coefficients between all variables are well below 0.6, suggesting that there is no serious collinear problem.

Table 3 – Overall description

Variables	Obs	Mean	S.D.	Min	Max
r_debt	12,361	0.0094	0.0253	-0.0974	0.0628
r_equity	12,361	0.0377	0.0352	0.0011	0.2071
Water_Vul	12,361	0.1924	0.0909	0.0646	0.3918
Water_Ins	12,361	0.0019	0.0007	0.000	0.0049
Water_Inv	12,361	0.0055	0.0034	0.0013	0.0256
ROA	12,361	0.0558	0.0451	0.0018	0.2280
BM	12,361	0.6289	0.2473	0.1219	1.1891
SIZE	12,361	22.3425	1.2456	20.1137	26.1395
LEV	12,361	0.4007	0.1832	0.0638	0.8365
TOVER	12,361	5.6654	0.7380	3.6735	7.1963
SHR	12,361	0.1551	0.1070	0.0172	0.5205
LGDP	12,361	10.7181	0.6788	8.4992	11.6151
GGROWTH	12,361	5.9859	2.0171	0.5000	9.3000

Table 5 presents the results of estimating the relationship between water vulnerability and corporate capital cost. In the full-sample regression, we find that water vulnerability is significantly positive to firm capital cost. Water vulnerability moving from the first quartile (0.1135) to the third quartile (0.2132) could add 0.177% to the cost of debt and 0.015% to the cost of equity. This finding confirms our previous assumption that water vulnerability has become a non-negligible risk for enterprises, and capital markets have begun to realize the existence of this risk. H1a and H1b has been proved.

Table 5 – Water vulnerability and corporate capital cost (2019-2023)

	cost of debt	cost of equity
Water_Vul	0.0177***	0.015***
	(3.12)	(2.92)
ROA	-0.0170**	0.4587***
	(-1.88)	(3.56)
BM	0.0028*	0.0651***
	(1.74)	(3.07)
SIZE	0.0009***	0.0050***
	(4.41)	(2.83)
LEV	-0.0020	0.0105**
	(-0.35)	(2.49)
TOVER	-0.0008*	0.0024***
	(-1.98)	(3.42)
SHR	-0.0074***	-0.0061**
	(-2.97)	(-2.12)
LGDP	0.0006	0.0014***
	(1.03)	(2.79)
GGROWTH	0.0002	0.0004**
	(0.01)	(2.23)
Constant	-0.0130	-0.1854***
	(-0.35)	(-3.04)
Fixed Effects	Yes	Yes
Obs	12363	12363

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively;
the values in parentheses represent the t-value after robust standard error adjustment

Table 4 – Correlation test

	Water_Vul	r_equity	r_debt	Water_Ins	Water_Inv	ROA	BM	SIZE	LEV	TOVER	SHR	LGDP	GGROWTH
Water_Vul		0.0447	0.0427***	-0.1642**	-0.1033**	-0.1244***	0.0553***	0.0999***	0.0492***	-0.0326***	0.0273***	-0.4710***	-0.0795***
r_equity	0.0128		0.0196**	-0.0218**	0.0083	0.5611***	0.4379***	0.4244***	0.1122***	-0.3078***	0.1565***	0.0284***	-0.0696***
r_debt	0.0379***	0.0485***		-0.0038	0.0048	-0.0542***	0.0612***	0.0815***	0.0494***	-0.0327***	-0.0137	-0.0382***	0.0007
Water_Ins	-0.2048***	-0.0238**	-0.0027		0.1280***	0.0239**	-0.0473***	-0.0553***	-0.0215**	0.0744***	-0.0212**	0.2269***	0.0595***
Water_Inv	0.0552***	0.0001	0.0177*	0.1705***		0.0001	-0.0031	0.0356***	0.0115	0.0393***	0.0121	-0.4681***	0.1281***
ROA	-0.1076***	0.3679***	-0.0444***	0.0152	-0.0283***		-0.3375***	-0.0909***	-0.3819***	-0.1053***	0.1294***	0.1228***	0.0151
BM	0.0774***	0.4343***	0.0716***	-0.0517***	0.0170***	-0.3718***		0.5178***	0.3962***	-0.2727***	0.0872***	-0.0665***	-0.0786***
SIZE	0.1328***	0.4554***	0.0827***	-0.0514***	0.0401***	-0.0767***	0.5318***		0.5249***	-0.3516***	0.1244***	-0.1314***	-0.0364***
LEV	0.0573***	0.1670**	0.0463***	-0.0153	0.0344***	-0.3656***	0.3947***	0.5323***		-0.0506***	0.0260***	-0.0694***	-0.0265***
TOVER	-0.0457***	-0.2538***	-0.0427***	0.0724***	0.0404***	-0.0998***	-0.2814***	-0.3859***	-0.0603***		-0.3103***	0.0763***	-0.1503***
SHR	0.0477***	0.1636***	-0.0051	-0.0274***	0.0100	0.1043***	0.1149***	0.2067***	0.0518***	-0.3561***		-0.0320***	0.0040
LGDP	-0.4495***	0.0053***	-0.0326***	0.1300***	-0.5435***	0.1071***	-0.0730***	-0.1277***	-0.0763***	0.0531***	-0.0401***		-0.1086***
GGROWTH	-0.0422***	-0.0368***	-0.0076	0.0889***	0.0811***	0.0085	-0.0319***	-0.0514***	-0.0238**	-0.1797***	0.0041	-0.0165*	

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively

5.2 Robustness

We conduct two robustness tests. First, we change another period of sample to test the robustness of the main regression. We use data from 30 Chinese provinces and municipalities (excluding Tibet and Hong Kong, Macao, and Taiwan) during the period of 2014-2018. The result in Table 6 shows that water vulnerability is also positively related to the cost of debt and the cost of equity.

Table 6 – Robustness

	Sample Change		PSM	
	cost of debt	cost of equity	cost of debt	cost of equity
Water_Vul	0.0212***	0.0106**	0.032**	0.021*
	(2.56)	(2.49)	(2.48)	(1.78)
Controls	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes
Constant	2.4132*	1.4594**	0.085***	0.011
	(1.75)	(2.41)	(2.81)	(1.34)
Obs	8736	8736	11476	11476

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively; the values in parentheses represent the t-value after robust standard error adjustment

Second, we use PSM to further investigate the robustness of baseline regression result. The principle of propensity matching is to compare firms with similar characteristics but inconsistent behaviors as a matching group. Since the geographical location of enterprises is their own choice, we select enterprises located in areas where water vulnerability is above the average as the treatment group, and enterprises located in areas where water vulnerability is below the average as the control group. In this paper, we use return on assets (ROA), price to book ratio (BM), total asset (SIZE), financial leverage (LEV), turnover of stocks (TOVER), Share Concentration (SHR) as matching variable, the samples are paired one-on-one. The regression coefficients of water vulnerability are positive and significant, indicating that the conclusion is still valid, as shown in Table 6.

5.3 Endogeneity Tests

We test the endogeneity of water vulnerability and capital costs because we initially regard that water vulnerability includes some indexes that are influenced by social and economic development. Despite we control some variables reflecting regional economic development, the variable of water vulnerability may still fail to meet the requirements of exogeneity due to the existence of omitted variables or measurement errors.

Follow the approach proposed by Wooldridge (2010) [95], we start with a random-effects model, as Eq. (3).

$$Capital_{it} = \alpha_1 + \beta_1 Water_Vul_{jt} + \sum Controls_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

$$Water_Vul_{jt} = \alpha_2 + \delta_1 SUN_{jt} + \beta\delta_2 \sum Controls_{it} + \omega_{it} \quad (4)$$

Then we introduce the variable of the annual hour of sunshine (SUN) to test whether water vulnerability meets the requirement of endogeneity. This paper considers that water vulnerability may be affected by regional economic development levels, but the average annual hour of sunshine is less affected by social and economic development levels than water vulnerability. Firstly, we obtain the residuals from Eq. (4) and include the residuals in the first Eq. (3). For the cost of equity (r_equity), the coefficient of the residual denoted VUL_hat is -0.0054 with a p-value of -0.370. For the cost of debt (r_debt), the coefficient of the residual denoted VUL_hat is -0.0116 with a p-value of -0.173. Hence, we reject the null hypothesis that the coefficient of the residual is equal to zero, suggesting that the water vulnerability (Water_Vul) is endogenous.

Table 7 – Endogeneity Test

	Water_Vul	r_equity	r_debt
Water_Vul		0.0096**	0.0132**
		(2.68)	(1.88)
VUL_hat		-0.0054	-0.0116
		(-0.37)	(-0.17)
SUN	0.2132***		
	(4.59)		
Controls	Yes	Yes	Yes
Constant	-1.1754***	-0.1792***	-0.0160*
	(-3.46)	(-5.68)	(-1.73)
Obs	12,361	12,361	12,361

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively;
the values in parentheses represent the t-value after robust standard error adjustment

5.4 Channel Analysis

In hypothesis, we present that water vulnerability exposes investors to higher credit risk so that improve corporate capital costs. Credit risk would result in financing constraints, so we apply financial constraints to measure credit risk. For the measurement of financing constraint, we draw on the research of Kaplan and Zingales (1997). The higher the value of the KZ, the greater the degree of financing constraints. The data of KZ are from CSMAR. We also draw on the method of Wen and Ye (2014) to construct models (5) - (7) to examine whether the mediating effect of financing constraint (KZ) exists. Eq. (5) is the main test model, and the coefficient α1 measures the total effect of the independent variable on the dependent variable. Eq. (6) is used to examine the impact of water vulnerability on financing constraints, and the coefficient β1 is the focus. Eq. (7) mainly examines the impact of water vulnerability and financing constraints on the corporate capital costs, and the coefficient γ1 and γ2 are the focus. If γ1 is insignificant but γ2 is significant, it indicates that financial constraints play a complete mediating effect. If γ1 and γ2 are both significant, it indicates that financial constraints play a partial mediating effect.

$$Capital_{it} = \alpha_0 + \alpha_1 Water_Vul_{jt} + \sum Controls_{it} + \sum_j \alpha_j\, Industrialfixed_j + \sum_l \alpha_l Yearfixed_l + \varepsilon_{it} \quad (5)$$

$$KZ_{it} = \beta_0 + \beta_1 Water_Vul_{jt} + \sum Controls_{it} + \sum_j \beta_j\, Industrialfixed_j + \sum_l \beta_l Yearfixed_l + \varepsilon_{it} \quad (6)$$

$$Capital_{it} = \gamma_0 + \gamma_1 Water_Vul_{jt} KZ_{it} + \sum Controls_{it} + \sum_j \gamma_j\, Industrialfixed_j + \sum_l \gamma_l Yearfixed_l + \varepsilon_{it} \quad (7)$$

Table 8 displays the results of channel analysis. The first step of the mediation effect test is presented in R1 and R4, which is also the outcome of the main regression in Eq. (1). The regression coefficient for water vulnerability on corporate capital costs is positively and significantly related with the significance of α_1. The results of step 2 are shown in R2 and R5. The regression coefficient of water vulnerability on financing constraints is positive and significant at the p<5% level, indicating that water vulnerability significantly promotes financing constraints. R3 and R6 present the outcomes of the third step, with the coefficients for water vulnerability and financing constraints both blow the significance at p<5% levels. This suggests that the increase in financing constraints, spurred by water vulnerability, contributes to the higher corporate capital costs, with financing constraints serving as a partial mediator.

Table 8 – Channel Analysis

	r_debt			r_equity		
	R1	R2	R3	R4	R5	R6
	r_debt	KZ	r_debt	r_equity	KZ	r_equity
Water_Vul	0.0177***	0.035**	0.0175***	0.015***	0.0007**	0.011***
	(3.12)	(2.17)	(3.35)	(2.92)	(2.03)	(3.06)
KZ			0.029**			0.3317***
			(2.84)			(2.98)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.0130	-0.0425	-0.0121	-0.1854***	-0.6143	-0.1720**
	(-0.35)	(-0.68)	(-0.93)	(-3.04)	(-0.54)	(-2.16)
Obs	12,361	12,361	12,361	12,361	12,361	12,361

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively; the values in parentheses represent the t-value after robust standard error adjustment

5.5 Moderating Effect

The results presented in Table 9 show that government water regulation generally exerts positive moderating effect on the relationship between water vulnerability and the cost of debt but exerts insignificantly negative moderating effect on the relationship between water vulnerability and the cost of equity. H2a has been proved, but H2b fails to hypothesis testing. The findings on the cost of debt echo the suggestion that government water regulation positively moderates the impact of water vulnerability on corporate financial performance (Zheng et al.,2022) [13], thus promoting creditors asking for more water risk premium. The findings of the cost of equity demonstrate that government water regulation could generally promote the green transformation of enterprises thereby reducing physical water risks and ensuring long-term sustainable development of enterprises.

The results presented in Table 9 also show that government water investment slightly negatively moderates the impact of water vulnerability on the cost of debt but has no significant moderating effects on reducing the impact of water vulnerability on the cost of equity. H3a has been proved, but H3b fails to hypothesis testing. The findings on the cost of debt echo the suggestion that government water investment negatively moderates the impact of water vulnerability on corporate financial performance (Zheng et al., 2022) [13], thus promoting creditors asking for less water risk premium. The results of the cost of equity indicate that government water investment could generally improve local water conditions and reduce the negative impact of water vulnerability, despite at an insignificant level.

Table 9 – Moderating Effects

	r_debt	r_equity
Water_Vul	0.0186***	0.0646***
	(2.61)	(3.88)
Water_Ins	0.0972	0.1790
	(1.03)	(1.24)
Water_Vul×Water_Ins	3.2678*	-1.8538
	(1.68)	(-0.98)
Water_Vul	0.0180***	0.0150***
	(2.75)	(2.94)
Water_Inv	0.2321*	0.0871
	(1.71)	(1.08)
Water_Vul×Water_Inv	-1.3972*	-0.1655
	(-1.67)	(-0.83)
Controls	Yes	Yes
Fix Effects	Yes	Yes
Obs	12363	12363

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively;
the values in parentheses represent the t-value after robust standard error adjustment

5.6 Heterogeneity

Since there are significant differences in water risk perception between water-intensive industries and non-water intensive industries, state-owned and non-state-owned corporates (Zheng et al.,2022) [13], this paper further investigates the two heterogeneities in the relationship between water vulnerability and corporate capital costs.

5.6.1 Industrial heterogeneity

The division of water-intensive industries is not unified at present. In this paper, ten industries whose water consumption data are regulated by the National Bureau of Statistics of China are regarded as water-intensive industries, they are coal mining and washing, ferrous metal smelting and rolling processing, non-metallic mining and selection, electric power and heat production and supply, textile, paper products industry, nonferrous metal smelting and rolling processing, chemical raw materials and chemical products manufacturing, non-metallic mineral products industry and petroleum processing, coking and nuclear fuel processing.

Table 10 exhibits the industrial heterogeneity in main regression. The significance of the coefficient of water vulnerability indicates that water vulnerability cannot significantly influence the capital cost of water-intensive firms, as shown in R1 and R5. This result seems strange and defies common sense. However, we argue that the reason why water vulnerability cannot significantly affect the capital cost of water-intensive enterprises is that these enterprises have established adaptive management of water resources to secure themselves from water vulnerability (Bulcke et al., 2020; Burritt et al., 2016; Northey et al., 2019) [96,15,30], for they are under much more formal institutional pressure than non-water intensive counterparts. For example, Callaghan et al. (2020) found that water-intensive corporates have strengthened their adaptation to water vulnerability through technological innovation and green transformation [97].

Table 11 exhibits the industrial heterogeneity in moderating effects. Panel A demonstrates the heterogeneity in moderating effect of water regulation. R1 and R2 show that the positive moderating effect is prominent in non-water intensive industries but not in the water-intensive group. We believe that water-intensive enterprises have already conducted adaptive

management and have long been monitored and regulated by the government (Bulcke et al., 2020; Burritt et al., 2016; Northey et al., 2019) [96,15,30], the water-related regulation risk is marginal diminishing. Therefore, the impact of water regulation is not significant to water-intensive enterprises but slightly significant in non- water-intensive industries.

Panel B demonstrates the heterogeneity in moderating effect of water investment. We find that the moderating effect of government water investment is significantly negative in water-intensive firms but significantly positive in non-water-intensive firms, as shown in R1 and R2, R5 and R6. As mentioned earlier, government investment in water can improve local hydrological conditions, and water-intensive firms already manage adaptively. As a result, water-intensive firms face significantly lower water risks, indicating a reduction in the risk premium demanded by investors. Government water investments may pay off in the long run through water price, and non-water intensive firms may have little awareness of adaptive water management. Thus, there may be a further squeeze on profits for non-water intensive firms, suggesting that investors are still considering a water risk premium.

5.6.2 Firm heterogeneity

We further divide the sample into state-owned and non-state-owned to test whether the ownership of enterprises buffers or intensifies the impact of water risk. Some scholars believed that state-owned enterprises could strengthen their profitability through natural resources rent (Lim & Morris, 2022) [98]. However, other scholars hold the opposite opinions that state-owned enterprises function as an instrument to enforce government policies, they may underperform in financial outcomes to reach non-commercial goals (Huang et al., 2020; Matuszak & Kabaciński, 2021). Water issues are highly related to human rights (Hazelton, 2013) [65], and state-owned enterprises need to bear more responsibilities to protect civil rights. For example, Huang et al. (2020) found that state-owned enterprises pay more pollutant discharge fees [99].

Table 10 shows that the impact of water vulnerability differs between the cost of debt and the cost of equity. For SOEs, it seems that creditors are more likely to ask for a water risk premium (R3), while equity investors do not care much about water risk to SOEs (R7). We ascribe the water risk premium of debt of SOEs to their financial underperformance because corporate solvency and corporate financial risk are one of the main factors influencing the cost of debt. SOEs may suffer more financial loss and SOEs tend to have higher debt ratios (Ferrarini & Hinojales, 2019) [100]. We interpret the carelessness of equity investors to water risk as SOEs are showing higher social responsibility performance to maintain their social and environmental legitimacy. Most of the research has proved that the higher the CSR performance could attribute to a lower cost of equity, and the past responsible performance could play prominent insurance effects to secure their equity (Afrin et al., 2021) [6]. Secondly, SOEs have natural political advantages in terms of resource acquisition, rent seeking and information risk (Chen et al., 2011; Zhou et al., 2018a, b) [101,87,88]. Compared with non-SOEs, SOEs are more conducive to rent-seeking and less likely to bear the cost of rent-seeking (Zhou et al., 2018a, b) [87,88]. Therefore, investors are less likely to seek a higher risk premium on the cost of equity of SOEs for their water risks, suggesting that equity investors will demand a higher risk premium from non-SOEs for their water risks. Our result shows that equity investors would add 0.239% to the cost of equity for non-SOEs if water risk moved from the first quartile (0.1135) to the third quartile (0.2132) (R8).

Table 11 exhibits that firm heterogeneity in moderating effects is mainly shown on the cost of debts. Panel A demonstrates the heterogeneity in moderating effect of water regulation. R3 demonstrates that government water regulation seems to have no significant impact on

SOEs. As interpreted before, SOEs may bear more responsibility for non-commercial goals, they are more likely to respond to government calls for adaptive water management. And the market would give additional credit to SOEs because of their governmental attributes (Xiao & Yang, 2021) [102], which may offset the negative impact of underperformance. Meanwhile, SOEs are more easily conducting power rent-seeking to reduce the adverse impact of policies without undertaking the cost of rent- seeking (Chen et al., 2011; Zhou et al., 2018a, b) [101,87,88]. Panel B demonstrates the heterogeneity in moderating effect of water investment. R3 demonstrates that government water investment is not a substitute for the continued social responsibility of SOEs in water issues.

Table 10 – Heterogeneity in Main Regression

	r_debt				r_equity			
	Industrial Heterogeneity		Firm Heterogeneity		Industrial Heterogeneity		Firm Heterogeneity	
	R1	R2	R3	R4	R5	R6	R7	R8
Water_Vul	0.0038	0.022***	0.0204**	0.0162**	0.0099	0.0127**	0.0016	0.0240***
	(0.36)	(2.67)	(2.45)	(2.02)	(1.10)	(1.88)	(0.19)	(2.86)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fix Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3246	9015	4001	8360	3246	9015	4001	8360
Chow Test	3.01**		2.75*		3.72**		4.72***	

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively; the values in parentheses represent the t-value after robust standard error adjustment

Table 11 – Heterogeneity in Moderating Effects

Panel A Water Regulation

	r_debt				r_equity			
	Industrial Heterogeneity		Firm Heterogeneity		Industrial Heterogeneity		Firm Heterogeneity	
	R1	R2	R3	R4	R5	R6	R7	R8
Water_Vul	0.0035	0.0229***	0.0235**	0.0170**	0.0135	0.0130**	0.0022	0.0261***
	(0.34)	(3.57)	(1.98)	(2.21)	(0.17)	(2.11)	(1.09)	(2.67)
Water_Ins	0.1735	0.0760	0.3408	0.0364	0.3205	0.0548	-0.0408	0.2202
	(0.39)	(0.73)	(0.12)	(0.24)	(0.81)	(0.52)	(0.18)	(1.25)
Water_Vul×Water_Ins	1.7515	4.0175*	3.6754	3.4806*	-2.4042	-2.4104	-4.9655	3.1467
	(1.08)	(1.82)	(1.59)	(1.92)	(-1.69)	(-1.42)	(-1.59)	(1.44)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fix Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3246	9015	4001	8360	3246	9015	4001	8360

Panel B Water Investment

	r_debt				r_equity			
	Industrial Heterogeneity		Firm Heterogeneity		Industrial Heterogeneity		Firm Heterogeneity	
	R1	R2	R3	R4	R5	R6	R7	R8
Water_Vul	0.0035	0.0222***	0.0209**	0.0158**	0.1123	0.0123**	0.0013	0.0235***
	(0.34)	(3.56)	(1.88)	(2.08)	(0.16)	(2.09)	(1.03)	(2.64)

Water_Inv	0.0902	0.2756*	0.1109	0.3020*	0.3458	-0.0686	-0.1131	0.2197*
	(0.22)	(1.85)	(0.37)	(1.94)	(0.84)	(-1.06)	(-0.17)	(1.77)
Water_Vul×Water_Inv	-0.1835*	1.7329*	-0.4043	-2.652**	-2.8680**	1.7997**	0.2560	0.1600
	(-1.69)	(1.79)	(-1.15)	(-2.24)	(-2.53)	(1.98)	(0.86)	(0.44)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fix Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3246	9015	4001	8360	3246	9015	4001	8360

Note: ***, **, * indicate significant at the 1%, 5% and 10% levels respectively; the values in parentheses represent the t-value after robust standard error adjustment

6. DISCUSSION AND CONCLUSION

First, Academics believe that the fundamental truth that natural resources are limited should be reiterated and cherished because of the effect it has on the viability of businesses. Our findings illustrate the negative impact of the deteriorating nature to corporate sustainability also rise from the access to financial resources. Companies in places with great exposure to water vulnerability exhibit higher financial costs, and water governance applied by the government could significantly influence the impact of water vulnerability. Specifically, water vulnerability positively relates to the cost of debt, and water regulation positive moderates while water investment negative moderates the impact. Water vulnerability positively relates the cost of equity, but both regulation and investment have no significant moderating effects on the relationship between water vulnerability and the cost of equity. The main findings align with some previous works. Zheng et al., (2022) and Huang et al., (2018) confirmed that ecological issues themselves does negatively impact corporate financial sustainability [13,45]. Based on their work, our finding with work done by Kling et al., (2021) further shows that the negative impact of ecological deterioration rise from the access to financial resources [44]. Meanwhile, the negative impact on the access to financial resources would not depend on the difference of environmental issues, although Bowen, Bansal, & Slawinski (2018) presented that the different environmental issues may cause different outcomes because the scale of variant environmental issues will cause different legal pressures for enterprises [103].

Second, we exam the moderating effect of two kind of water governance tools, namely, water regulation and water investment. Our findings show that water regulation is another risk factor associate water vulnerability because it can positively moderate the impact of water vulnerability on corporate capital cost. This finding is consistent with Tan et al., (2022) that external regulation pressure further enhances the impact of environment issues on the corporate capital cost [49]. And we offer further evidence to the opinion that environment institution brings economic cost to firms (Greenstone et al., 2012; Long & Wan, 2017) [78,79], and the finding support the government in increasing the scale of green credit to enterprises to solve the capital cost problem of enterprises during their green transformation. Our findings also show that water investment slight negatively moderate the relationship between water vulnerability and the cost of debt in general. This finding proves the economic value at micro level that water investment to alleviate water risk benefits corporate financing activities, which is in lines with previous studies that illustrate the improvement of water conditions could promote economic growth because reducing the financing cost of enterprises is conducive to enhancing the economic vitality of enterprises and promoting the development of regional economy (Huang et al.,2018; Kling et al.,2021) [44,45].

Third, we re-exam the relationship above in different sub-sampling and find some interesting results. Water-intensive enterprises seem immune to water vulnerability, for they may have conducted water adaptative management. The effect of water institution pressure on them seems to diminish and water investment may generate short-term harm but have long-term benefits. Non- water intensive enterprises are vulnerable to water vulnerability and are sensitive to regulation and government investment in water. This may be due to their carelessness in water adaptive management. These findings are consistent with Natural Resource Dependence Theory, which suggests that the degradation of ecosystems reduces the reliability of natural resource supplies, thereby increasing the environmental uncertainty faced by firms (Tashman, 2021; Tashman & Rivera, 2016) [10,11]. As the supply of natural resources is not in the hands of external organizations and firms do not have the means to internalize the supply of natural resources through mergers and acquisitions or strategic alliances, firms may respond to natural resource scarcity in a variety of ways, but only through those methods to reduce resource dependence can adverse changes brought about by ecological uncertainty be mitigated. (Tashman & Rivera, 2016) [11]. Our findings also consistently shows that symbolic change activities such as seeking the change of corporate identity cannot reduce the adverse impact of ecological uncertainty, and firms, by taking such practical actions as strengthening the ability of water resources management, can improve their ability to deal with ecological uncertainty.

Our results have significant implications for economic development. Firstly, water vulnerability matters to firms. Enterprises should work together to build water security; especially non-water intensive enterprises should establish the awareness of water risk and conduct water adaptive management and non-SOEs should share the responsibility for water issues. Secondly, the relatively low level of pressure from government water regulation hasn't had a serious impact on businesses at present, but it has also failed to further raise the attention of water issues for businesses. Strengthening water institutional pressure is needed. However, the negative impact on businesses will need to be considered when increasing the pressure on water regulation in the future. Thirdly, water investments are generally beneficial in mitigating regional water vulnerability, although there may be some negative impact on businesses due to the internalization of those spending. Firms that conduct water adaptive management could reduce this cost issue, thus establishing competitive advantages.

7. LIMITATION AND FUTURE RESEARCH

This study is subject to some limitations. First, although we attempted to employ as full a dataset as possible of all listed firms in the Chinese main board market, there may still be a selection bias because listed firms are a relatively small subset of all companies in China. Therefore, one should be cautious when interpreting our results for general Chinese firms. Second, although we took as many commonly used indicators to measure water vulnerability as possible, the indicators of water vulnerability are far from agreed upon. Hydrologists are still striving to explore more accurate indicators and methods to measure water vulnerability. More measurements of water vulnerability could be used to re-examine the relationship between physical water risk and firm financial outcomes. Thirdly, we find that water investment only negatively moderates the relationships between water vulnerability and the cost of debt at a slight significance and have no significantly moderating effect on the relationships between water vulnerability and the cost of equity. However, we have read the current literature and failed to find a better explanation. Thus, future research could further investigate to get more robust and reasonable explanation. Finally, this paper is a preliminary

study of the microeconomic consequences of water vulnerability. Due to the limitations mentioned above, the conclusions of this paper need to be supported by more studies. Therefore, caution should be exercised when using the conclusions of this article.

ACKNOWLEDGEMENT:

Author contribution: Conceptualization, Methodology, Writing – original draft, Formal analysis, Gao Pengqun; Supervision, Writing –editing and review Zheng Liyuan and Li Ling; Diagrams, Data preprocessing, Tao Bianshiyu and Lai Huaqiang.

Funding: This research was partly supported by Jiangsu Open University (Jiangsu City Vocational College) 14th Five-Year 2023 Annual Research Planning Project (Grant no. 2023XK011); 2023 Annual Jiangsu Province Social Education Planning Project (Grant no. JSS-C-2023033).

Data availability: The data involved in the study can be obtained from the corresponding author at reasonable request.

Consent to Participate and Consent for publication: All authors agree.

Competing interests: The authors declare no competing interests.

REFERENCES

[1] CEO Water Mandate. The CEO water mandate transparency framework (phase one)., Pacific Institute: Oakland, CA, USA, 2008.

[2] World Economic Forum. (2017). The global risks report 2016., World Economic Forum: Geneva, Switzerland, 2017.

[3] Jones, P., Hillier, D., & Comfort, D. Corporate water stewardship. *Journal of Environmental Studies and Sciences*, **2015**, 5(3), 272–276.

[4] Tello, E. From Risks to Shared Value? Corporate Strategies in Building a Global Water. Accounting and Disclosure Regime. *Water Alternatives*, **2013**, 5(3), 636–657.

[5] Zhu, Y., Zhang, CZ., Wang, T., & Miao, YJ. Corporate water risk: A new research hotspot under climate change. *Sustainable Development*, **2024**, 32(3), 2623-2637.

[6] Afrin, R., Peng, N., & Bowen, F. The Wealth Effect of Corporate Water Actions: How Past Corporate Responsibility and Irresponsibility Influence Stock Market Reactions. *Journal of Business Ethics*, **2022**, 180(1), 105-124.

[7] Liu CY., Zhou ZT., Su K., Liu K., & An H. Water risk and financial analysts' information environment: Empirical evidence from China. *Business Strategy and the Environment*, **2024**, 33(2), 1265-1304.

[8] Dias, C., Rodrigues, R. G., & Ferreira, J. J. Linking natural resources and performance of. small agricultural businesses: Do entrepreneurial orientation and environmental sustainability orientation matter? *Sustainable Development*, **2022**,30(4),713-725.

[9] George, G., Schillebeeckx, S. J. D., & Lit Liak, T. The management of natural resources: An overview and research agenda. *Academy of Management Journal*, **2015**, 58(6), 1595–1613.

[10] Tashman, P. A Natural Resource Dependence Perspective of the Firm: How and Why Firms. Manage Natural Resource Scarcity. *Business & Society*, **2021**, 60(6), 1279–1311.

[11] Tashman, P., & Rivera, J. (2016). Ecological uncertainty, adaptation, and mitigation in the U.S. ski. resort industry: Managing resource dependence and institutional pressures: Ecological Uncertainty, Adaptation, and Mitigation. *Strategic Management Journal*, 37(7), 1507–1525.

[12] Xia, J.; Weng, J.; Chen, J.; Qiu, B. Multi-scale Water Vulnerability Assessment Research. *Journal of Basic Science and Engineering*, **2014**, 20, 1–14.

[13] Zheng, L.; Ye, L.; Wang, M.; Wang, Y.; Zhou, H. Does Water Matter? the Impact of Water Vulnerability on Corporate Financial Performance. *Int. J. Environ. Res. Public Health*, **2022**, 19, 11272.

[14] Gui, Z., Chen, X., & He, Y. Spatiotemporal analysis of water resources system vulnerability in the Lancang River Basin, China. *Journal of Hydrology*, **2021**, 601, 126614.

[15] Burritt, R. L., Christ, K. L., & Omori, A. Drivers of corporate water-related disclosure: Evidence from Japan. *Journal of Cleaner Production*, **2016**, 129, 65–74.

[16] Ortas, E., Burritt, R. L., & Christ, K. L. The influence of macro factors on corporate water. management: A multi-country quantile regression approach. *Journal of Cleaner Production*, **2019**, 226, 1013–1021.

[17] Sojamo, S., & Rudebeck, T. Corporate Engagement in Water Policy and Governance: A Literature Review on Water Stewardship and Water Security. *Water Alternatives-An interdisciplinary journal on water politics and development*, **2024**,17(2), 292-324.

[18] Li ZH., & Yuan BB. Environmental policy mechanism of local governments in the treatment of haze pollution: Policy tools, spatial correlations and threshold effects. *Resources Science*, **2021**, 43(01), 40–56.

[19] Ban L., & Liu XH. The Study of Emission Reduction Effects of Different. Environmental Regulations on the Different Environmental Pollution Types. *Ningxia Social Sciences*, **2021**, 05, 140–151.

[20] Ma H., & Hou GS. Smog Pollution, Local Government Behavior and Enterprise. Innovation Intention--Based on the Empirical Data of Listed Manufacturing Companies. *Soft Science*, **2020**, 34(02), 27–32.

[21] Cui G., & Jiang YB. The Influence of Environmental Regulation on the. Behavior of Enterprise Environmental Governance: Based on a Quasi-Natural Experiment of New Environmental Protection Law. *Business and management Journal*, **2019**, 41(10), 54–72.

[22] Yuan, Y. & Zheng, Y. Progress and future prospects of water resources vulnerability at home and abroad. *Journal of Arid Land Resources and Environment*, **2022**, 36(7), 116-125.

[23] Jenkins, K., Dobson, B., Decker, C., Hall, JW. An Integrated Framework for Risk-Based Analysis of Economic Impacts of Drought and Water Scarcity in England and Wales. *Water Resources Research*, **2021**, 57(8), e2020WR027715.

[24] Ugochukwu, UC, Chukwuone N., Jidere C.,et al., Heavy metal contamination of soil, sediment and water due to galena mining in Ebonyi State Nigeria: Economic costs of pollution based on exposure health risks. *Journal of Environmental management*, **2022**, 32,1115864.

[25] Temkin, A., Evans, S., Manidis, T., Campbell, C., Naidenko, OV. Exposure-based assessment and economic valuation of adverse birth outcomes and cancer risk due to nitrate in United States drinking water. *Environmental Research*, **2019**, 176, 108442.

[26] Gleick, PH. Water, Drought, Climate Change, and Conflict in Syria. *Weather Climate and Society*, **2014**, 6(3), 331-340.

[27] Schilling J., Hertig E., Tramblay Y., & Scheffran J. Climate change vulnerability, water resources and social implications in North Africa. *Reginal Environmental Change*, **2020**, 20(1), 15.

[28] Bonnafous, L., Lall, U., & Siegel, J. A water risk index for portfolio exposure to climatic. extremes: Conceptualization and an application to the mining industry. *Hydrology and Earth System Sciences*, **2017**, 21(4), 2075–2106.

[29] Muthulingam S., Dhanorkar S., & Corbett C. J. Does Water Scarcity Affect Environmental Performance? Evidence from Manufacturing Facilities in Texas. *Management Science*, **2022**, 68(4),2785-2805.

[30] Northey, S. A., Mudd, G. M., Werner, T. T., Haque, N., & Yellishetty, M. Sustainable water. management and improved corporate reporting in mining. *Water Resources and Industry*, **2019**, 21, 100104.

[31] Jagannathan, R., Liberti, J., Liu, BY., Meier, I. A Firm's Cost of Capital. *Annual Review of Financial Economics*, **2017**, 9,259-282.

[32] Lyu, Y., Ji, Z., Zhang, XQ., & Zhan, Z. Can Fintech Alleviate the Financing Constraints of Enterprises? – Evidence from the Chinese Securities Market. *Sustainability*, **2023**, 15(5),3876.

[33] Benlemlih, M. Corporate social responsibility and firm financing decisions: A literature review. *Journal of Multinational Financial Management*, **2017**, 42-43,1-10.

[34] Sassi, S., Saadi, S., Boubaker, S., & Chourou, L. External Governance and the Cost of Equity Financing. *Journal of Financial Research*, **2019**, 42(4),817-865.

[35] Li, ZS., Liu, C., Ni, X., & Pang, JR. Stock market liberalization and corporate investment revisited: Evidence from China. *Journal of Banking & Finance*, **2024**, 158,107053.

[36] Daouk, H., Lee, CMC., & Ng, D. Capital market governance: How do security laws affect market performance?. *Journal of Corporate Finance*, **2006**, 12(3),560-593.

[37] Amairi, H., Gallali, MI., & Sassi, S. Market pressure and cost of equity: Revisited. *Financing Research Letters*, **2022**, 47(Part B),102749.

[38] Hillier, D. & Loncan, T. Stock market integration, cost of equity capital, and corporate investment: Evidence from Brazil. *European Financial Management*, **2019**, 25(1),181-206.

[39] Vega-Gutierrez, PL., López-Iturriaga, FJ., & Rodriguez-Sanz, JA. Labour market conditions and the corporate financing decision: A European analysis. *Research in International Business and Finance*, **2021** ,58, 101431.

[40] Xie, HB., & Lin, C. Economic policy uncertainty and directors and officers liability insurance: a perspective on capital market pressures. *Geneva Papers on Risk and Insurance-issues and Practice*, **2023**. (Early Access)

[42] Sheng MQ., Wang S., & Zhang CH. Monetary Policy, Interest Rate Transmission and the Financing Cost of Small and Medium Enterprises: An Empirical Analysis Based on Actual Financing Costs. *Economic Review*, **2017**, 05, 28-39+90.

[42] Lendvai, J., Raciborski, R., & Vogel, L. Macroeconomic effects of an equity transaction tax in a general- equilibrium model. *Journal of Economic Dynamics & Control*, **2013**, 37(2),466-482.

[43] Truong, C., Nguyen, TH., & Huynh, T. Customer satisfaction and the cost of capital. *Review of Accounting Studies*, **2021**, 26(1),293-342.

[44] Kling, G., Volz, U., Murinde, V., & Ayas, S. The impact of climate vulnerability on firms' cost of capital and access to finance. *World Development*, **2021**, 137, 105131.

[45] Huang, H. H., Kerstein, J., & Wang, C. The impact of climate risk on firm performance and. financing choices: An international comparison. *Journal of International Business Studies*, **2018**, 49(5), 633–656.

[46] Yildiz, Y., & Temiz, H. Climate change exposure, environmental performance, and the cost of capital in the energy sector: Fossil fuel versus renewable energy firms. *Managerial and Decision Economics*, **2024**. (Early Access).

[47] Du, J., Xu, XY., & Yang, Y. Does Corporate Climate Risk Affect the Cost of Equity——Evidence from Textual Analysis with Machine Learning. *Chinese Review of Financial Studies*, **2023**, 15(03),19-46+125.

[48] Liu XH. Public Pressure, Property Rights Nature, and Corporate Financing Behavior: A Study Based on the "PM2.5 Burst" Event. *Economic Science*, **2016**, (02),67-80.

[49] Tan, J., Chan, K. C., & Chen, Y. The impact of air pollution on the cost of debt financing: evidence from the bond market. *Business Strategy and the Environment*, **2022**, 31(1),464-482.

[50] Nguyen T., Bai M., Hou G., & Truong C. Drought risk and capital structure dynamics. *Accounting & Finance*, **2022**, 62(3), 3397-3439.

[51] Heikkila, T. Evidence for Tackling the Complexities of Water Governance. *Public Administration Review*, **2017**, 77(1),17-20.

[52] Harley, C., Metcalf, L., & Irwin, J. An Exploratory Study in Community Perspectives of Sustainability Leadership in the Murray Darling Basin. *Journal of business Ethics*, 2014, 124(3),413-433.

[53] Li, TN., Zeng, XT., Chen, C., et al. Scenario Analysis of Initial Water-Rights Allocation to Improve Regional Water Productivities. *Wa*ter, **2019**, 11(6), 1312.

[54] Lu JY., Zhou NX., Zhou ZF., & Zeng HX. Effect and mechanism of 'the Ten-point Water Plan' on the intensity of industrial water pollution. *China Population Resources and Environment*, **2021**, 31, (2),90-99.

[55] Lin, XC., Chen, GF., Ni, HZ., et al. Impact of Water Saving Policy on Water Resource and Economy for Hebei, China Based on an Improved Computable General Equilibrium Model. *Water*, **2022**, 14(13), 2056.

[56] Luckmann, J., Flaig, D., Grethe, H., & Siddig, K. Modelling Sectorally Differentiated Water Prices - Water Preservation and Welfare Gains Through Price Reform? *Water Resources Management*, **2016**, 30(7), 2327- 2342.

[57] Zhou, Q., Wang, YY., Zeng, M., et al. (2021). Does China's river chief policy improve corporate water disclosure? A quasi-natural experimental. *Journal of Cleaner Production*, **2021**, 311,127707.

[58] Li, LY., Uyttenhove, P., & Vaneetvelde, V. Planning green infrastructure to mitigate urban surface water flooding risk - A methodology to identify priority areas applied in the city of Ghent. *Landscape and Urban Planning*, **2020**, 194, 103703.

[59] Adeniran, A., Daniell, KA., & Pittock, J. Water Infrastructure Development in Nigeria: Trend, Size, and Purpose. *Water*, **2021**, 13(17),2416.

[60] Long, D., Yang, WT., Scanlon, BR., et al. South-to-North Water Diversion stabilizing Beijing's groundwater levels. *Nature Communication*, **2020**, 11(1), 3665.

[61] Meehan, KM. Tool-power: Water infrastructure as wellsprings of state power. *Geoforum*, **2014**, 57,215-224. [62] Baudoin, L., & Arenas, D. From Raindrops to a Common Stream: Using the Social-Ecological Systems Framework for Research on Sustainable Water Management. *Organization & Environment*, **202**0, 33(1), 126–148.

[63] Yang, MM., Qin, CH., Zhu, YN., et al. Assessment of Multi-Regional Comprehensive Benefits of the South- to-North Water Diversion Project in China. *Water*, **2024**, 16(3), 473.

[64] Appiah, D. O., & Abass, K. Water supply and mining: The policy paradox in Ghana. *Water Policy*, **2014**, 16(5), 945–958.

[65] Hazelton, J. Accounting as a human right: The case of water information. *Accounting, Auditing & Accountability Journal*, **2013**, 26(2), 267–311.

[66] Vos, J., & Hinojosa, L. Virtual water trade and the contestation of hydrosocial territories. *Water International*, 2016, 41(1), 37–53.

[67] Martinez, F. A Three-Dimensional Conceptual Framework of Corporate Water. Responsibility. *Organization & Environment*, **201**5, 28(2), 137–159.

[68] Fogel, D., & Elizabeth Palmer, J. Water as a corporate resource. *Journal of Global. Responsibility*, **2014**, 5(1), 104–125.

[69] Wang M., Xu X., Zheng L., et al., Analysis of the Relationship between Economic Development and Water Resources–Ecological Management Capacity in China Based on Nighttime Lighting Data. *Int. J. Environ. Res. Public Health*, **2023**, 20,1818. https://doi.org/10.3390/ ijerph20031818

[70] Christ K L. Water management accounting and the wine supply chain: Empirical evidence from Australia. *The British Accounting Review*, **2014**, 46(4),379-396.

[71] Sun, M., & Kato, T. Spatial-temporal analysis of urban water resource vulnerability in. China. *Ecological Indicators*, **2021**, 133, 108436. https://doi.org/10.1016/j.ecolind.2021.108436

[72] Jiao, S., Li, W., & Wen, J. Spatiotemporal changes of manufacturing firms in the flood. prone Yangtze Delta. *Environmental Hazards*, 2022,21(4), 334-360.

[73] Song YH., Ma LL., Yang LJ, et, al. Business interruption risk analysis based. on fuzzy BN: a case study of flood disaster, *China Safety Science Journal*, **2019**, 29(06),1-6.

[74] Qin, Y., Harrison, J., & Chen, L. A framework for the practice of corporate environmental. responsibility in China. *Journal of Cleaner Production*, **2019**, 235, 426–452.

[75] Li ZH. The Impact of Public Participation on Local Government's Environmental Governance--An Analysis of Provincial Data 2003-2013. *Chinese Public Administration*, **2017**, 33(8), 102–108.

[76] Egan, M. Driving Water Management Change Where Economic Incentive is Limited. *Journal of Business Ethics*, **2015**,132(1), 73–90.

[77] Lambooy, T. Corporate social responsibility: Sustainable water use. *Journal of Cleaner Production*, **2011**, 19(8), 852–866.

[78] Greenstone, M.; List, J.A.; Syverson, C. The Effects of Environmental Regulation on the Competitiveness of U.S. Manufacturing; MIT Department of Economics Working Paper No. 12–24; NBER: Cambridge, MA, USA, **2012**; Available online: http://www.ssrn.com/abstract=2145006 (accessed on 28 April 2021).

[79] Long XN., & Wan W. Environmental Regulation, Corporate Profit Margins and Compliance Cost Heterogeneity of Different Scale Enterprises. *China Industrial Economics*, **2017**, 6, 155–174.

[80] Yan, X., Zhang, Y., & Pei, LL. The impact of risk-taking level on green technology. innovation: Evidence from energy-intensive listed companies in China. *Journal of Cleaner Production*, **2021**, 281, 124685.

[81] Petts, G., & Gurnell, A. Hydrogeomorphic Effects of Reservoirs, Dams, and Diversions. *Treatise on Geomorphology*, **2022**, 9, 144–166.

[82] Qu, X., Chen, Y., Liu, H., Xia, W., Lu, Y., Gang, DD., & Lin, LS. A holistic assessment. of water quality condition and spatiotemporal patterns in impounded lakes along the eastern route of China's South-to-North water diversion project. *Water Research*, **2020**, 185, 116275.

[83] Liu QQ., & Chen Y. Assessing the Vulnerability of Basin Water Resources Based. on Entropy Weight Method: A Case Study of the Huaihe River basin. *Journal of Yangtze River Scientific Research*, **2016**, 33(9), 10–17.

[84] Su XB., Li XG., Liu JF, et al,. Vulnerability assessment of water resources in the northwest typical area based on comprehensive weighting method. *Journal of Arid Land Resources and Environment*, **2018**, 32(3), 112–118.

[85] Zou, H., Bryan ADAMS, M., & M J, B. Corporate risk and property insurance: Evidence. from the People's Republic of China. *Journal of Risk and Insurance*, **2003**, 70(2):289-314.

[86] Mao XS, Ye KT, & Zhang D. Measuring and Evaluating Cost of Equity Capital: Evidence from Chinese Stock Markets. *Accounting Research*, **2012**, 11, 12-22+94.

[87] Lin ZG., Zheng J., & Bo SJ. Environmental uncertainty, diversification and the cost of capital. *Accounting Research*, **2015**, 2, 36-43+93.

[88] Zhou, Z., Zhou, H., Zeng, H., & Chen, X. The impact of water information disclosure on the cost of capital: An empirical study of China's capital market. *Corporate Social Responsibility and Environmental Management*, **2018**, 25(6), 1332–1349. https://doi.org/10.1002/csr.1643

[89] Zhou, Z., Zhou, H., & Zeng, H.. Water Information Disclosure, Political Connections and Cost of Capital: Evidence from High Water Sensitivity Industry of 2010 to 2015. *Journal of Central South University (Social Sciences)*, **2018**, 24(02), 96–108.

[90] Chen SY, & Chen DK. Air Pollution, Government Regulations and High-quality Economic Development. *Economic Research Journal*, **2018**, 53(02), 20–34.

[91] Chen, Z., Kahn, M. E., Liu, Y., & Wang, Z. The consequences of spatially differentiated. water pollution regulation in China. *Journal of Environmental Economics and Management*, **2018**, 88, 468–485.

[92] Han, X., Wang, P., Wang, J., Qiao, M., & Zhao, X. Evaluation of human-environment. system vulnerability for sustainable development in the Liupan mountainous region of Ningxia, China. *Environmental Development*, **2020**, 34, 100525.

[93] Qiu W., Zhao QL., Li S., et al,. Ecological Security Evaluation of Heilongjiang. Province with Pressure-State- Response Model. *Environmental Science*, **2008**, 04, 1148–1152.

[94] Cao XF, Hu CZ, Qi XW, et al. Strategies for Water Resources Regulation. and Water Environment Protection in Beijing-Tianjin-Hebei Region. *Strategic Study of CAE*, **2019**, 21(5), 130–136.

[95] Wooldridge, J.M. Econometric Analysis of Cross Section and Panel Data; MIT Press: New Haven, CT, USA, **2010**.

[96] Bulcke, P., Vionnet, S., Vousvouras, C., & Weder, G. Nestlé's corporate water strategy over time: A backward- and forward-looking view. *International Journal of Water Resources Development*, **2020**, 36(2–3), 245–257.

[97] O'Callaghan, P., Adapa, L. M., & Buisman, C. How can innovation theories be applied to. water technology innovation? *Journal of Cleaner Production*, **2020**, 276, 122910.

[98] Lim, K. Y., & Morris, D. Thresholds in natural resource rents and state-owned enterprise. profitability: Cross country evidence. *Energy Economics*, **2022**, 106, 105779.

[99] Huang, L., Liu, S., Han, Y., & Peng, K. The nature of state-owned enterprises and collection. of pollutant discharge fees: A study based on Chinese industrial enterprises. *Journal of Cleaner Production*, **2020**, 271, 122420.

[100] Ferrarini, B., & Hinojales, M. State-Owned Enterprises and Debt Sustainability Analysis: The Case of the People's Republic of China. *Journal of Asian Finance, Economics and Business*, **2019**, 6(1), 91–105.

[101] Chen, H., Chen, J. Z., Lobo, G. J., & Wang, Y. Effects of Audit Quality on Earnings. Management and Cost of Equity Capital: Evidence from China. *Contemporary Accounting Research*, **2011**, 28(3), 892–925.

[102] Xiao X., & Yang X. Probability of Default, Financing Costs, and Third-Party Credit Enhancement Effect: An Analysis of Private Corporate Bonds. *Financial Economics Research*, **2021**, 36(2), 87–98.

[103] Bowen, F. E., Bansal, P., & Slawinski, N. Scale matters: The scale of environmental issues in corporate collective actions. *Strategic Management Journal*, **2018**, 39(5), 1411–1436.

DECENTRALIZED WEB3 PLATFORM ENHANCED WITH AI AND IOT FOR URBAN COMMUNITY FARMING: A STRATEGIC APPROACH TO ACHIEVING SOCIETY 5.0

Kwan Jun Er[A], Shahrinaz Ismail[B]

ABSTRACT

In response to rapid urbanization and the pressing societal challenge of sustainable food production and food security, urban community farming has emerged as a viable solution. This research aims to enhance food security, increase income, foster community engagement, and improve sustainable food production through efficient resource use. To achieve these objectives, the study develops a decentralized Web3 platform integrated with Artificial Intelligence (AI) and the Internet of Things (IoT), aligned with Society 5.0—a super-smart society that leverages advanced technologies to address societal challenges. The methodology involves collecting data through semi-structured interviews and surveys to assess user needs and expectations. The research explores the use of the Ethereum blockchain for decentralized operations, selects suitable AI models for actionable insights on crop selection, soil health, and resource optimization, and identifies cost-effective IoT products for urban farming. Blockchain technology ensures transparency, traceability, and secure management of resources and data. AI-driven recommendations support tailored farming practices, while an auto-matching feature facilitates the sale of agricultural products. IoT devices provide real-time monitoring of environmental conditions, enabling automated irrigation and climate control. Preliminary results indicate positive feedback from participants, with expected increases in crop yields, improved food security, and potential income growth. The result also reveals enhanced community involvement and collaboration. In conclusion, this study demonstrates how integrating Web3, AI, and IoT technologies can create a resilient urban farming ecosystem while promoting self-sufficiency in urban communities, aligning with Society 5.0' goals of sustainability and technological advancement.

Keywords: *Urban Community Farming, Web 3.0, Artificial Intelligence (AI), Internet of Things (IoT), Society 5.0, Blockchain*

1. INTRODUCTION

Food security has long been central to human survival, health, and stability throughout civilizations (Andersen, 2009). Yet today, food security is a growing global concern. Rapid urbanization, population growth, and climate change are intensifying the demand for

[A] *Bachelor's Degree, School of Technology, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: jonastheitguy@gmail.com*

[B] *PhD in ICT, School of Technology, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. shahrinaz.ismail@apu.edu.my Orcid: https://orcid.org/0000-0002-2960-1083*

sustainable food sources, while persistent issues such as affordability, availability, and quality of food further deepen food insecurity. In 2022, the Global Food Security Index (GFSI) reported a decline in two of its traditionally strongest pillars—affordability and food quality and safety—highlighting the vulnerability of food systems (Economist Impact, n.d.). Weaknesses in sustainability and adaptability continue to pose serious challenges, revealing the urgent need for resilient solutions.

Population growth, projected to reach nearly 10 billion people by 2050, requires a 60% increase in global food production to meet basic dietary needs, even as climate change accelerates (World Bank Group, n.d.). At the same time, expanding urban areas reduce arable land, forcing a re-evaluation of food production strategies. By 2018, the United Nations reported that 55% of the world's population lived in urban areas, a figure expected to rise, placing further pressure on available agricultural land (United Nations, 2018). Urban development competes with agricultural land, and the growing demand for animal-source foods (ASF) further complicates food security, with livestock essential yet resource-intensive.

The COVID-19 pandemic also exposed vulnerabilities in global food supply chains, exacerbating food insecurity as fragile systems were strained. In 2020, an estimated 30% of the global population experienced food insecurity, which has a 4% increase from the previous year, with impacts varying significantly across regions (Food and Agriculture Organization of the United Nations, n.d.). Rising food prices due to import reliance and supply chain disruptions have further complicated access to diverse, nutritious food. The Food Price Index, which averaged 87.84 points from 1990 to 2024, hit a record high of 160.20 points in March 2022, illustrating the severe pressure on global food markets (Trading Economics, n.d.).

Efforts to close the gap in food security include encouraging smallholder farmers to increase production and adopting fair trading practices. However, smallholder farmers often lack access to necessary financing, technology, and knowledge, which limits their productivity. Similarly, promoting fair trade practices faces obstacles in implementation and enforcement, indicating the need for alternative, sustainable approaches to food security.

In response, urban community farming has emerged as a promising solution to increase local food production, improve food accessibility, reduce dependency on external sources, and strengthen local economies. Community-based participatory programs within urban farming can mobilize resources, engage residents, and foster resilience against food insecurity (Doustmohammadian et al., 2022).

This research seeks to advance urban food security by developing a decentralized Web3 platform that integrates Artificial Intelligence (AI) and the Internet of Things (IoT) to support sustainable food production and efficient resource use. Inspired by the Society 5.0 vision—a super-smart society that harnesses advanced technologies to address pressing societal challenges—this platform is designed to enhance food resilience, foster community engagement, and create economic opportunities. Using blockchain technology for transparency, traceability, and secure resource management, combined with AI-driven recommendations for crop selection, soil health, and resource optimization with IoT devices enable real-time environmental monitoring to improve efficiency, the platform provides a robust foundation for urban farming.

Preliminary results suggest improvements in food security, community collaboration, and economic resilience. This study demonstrates that integrating Web3, AI, and IoT can build a resilient, self-sustaining urban food ecosystem, aligning with Society 5.0's goals of sustainability and technological advancement.

2. LITRATURE REVIEW

2.1 Urban Community Farming

Urban community farming, the cultivation of food and other agricultural products in urban or peri-urban areas, has become a vital practice worldwide (Srinivasan & Yadav, 2023). Defined as production occurring within or near city boundaries, urban community farming spans a range of activities and serves as a critical element in food systems for urban populations. It includes not only the cultivation of vegetables and fruit trees but also specialized crops such as medicinal plants, ornamental plants, wood, and even small-scale livestock rearing (Ghosh, 2004). By recycling organic waste and using city water sources, urban community farming plays an essential role in managing natural resources and promoting environmental sustainability (FAO, 2010).

The benefits of urban community farming extend well beyond food production. It improves community cohesion, promotes physical health, enhances environmental sustainability, and creates new economic opportunities. As a response to food security concerns, urban farming has recently gained momentum, where it is viewed as a means to meet urban food needs independently while also improving environmental conditions (Weidner et al., 2018). Furthermore, by growing food within urban areas, the need for long-distance transportation is reduced, helping to lower fuel consumption and emissions (Orsini et al., 2013).

In China, urban community farming is evident in three main forms: small-scale, capital-intensive, and tourism oriented (Zhu et al., 2024). Small-scale urban farming is primarily run by residents and small entrepreneurs who grow food for local markets (Horowitz & Liu, 2017). The Chinese government has also fostered the expansion of urban green spaces through initiatives like the Sponge City Program (SCP), which promotes Green Infrastructure to mitigate urban water resource and environmental issues. SCP incorporates rain gardens, urban parks, and forested areas, offering recreational benefits and engaging the community in green space expansion (Chan et al., 2022; Mitchell et al., 2022). In Guiyang, local authorities have partnered with private developers to create rain gardens and parks, selecting vegetation that benefits both urban infrastructure and community involvement (Qi et al., 2021). This model provides a foundation for further integrating nature-based solutions (NBS) and citizen science to support sustainable urban living.

Capital-intensive urban farming, such as hydroponics, aeroponics, aquaponics, and plant factories, requires significant investment and is typically privately owned. These operations, often in collaboration with academia and industry, are well-positioned to adopt advanced technology and innovative farming methods, enabling efficient and high-yield production within urban areas (Hayashi, 2016). Similarly, tourism-oriented urban farming is driven by private entities that operate peri-urban agro-tourism farms, offering city dwellers access to natural spaces. This practice enhances the appearance of urban outskirts and fosters recreational activities, with the government playing a pivotal role in promoting agro-tourism

that integrates ecological and agricultural elements, thus preserving farmland in rapidly urbanizing areas.

Urban community farming has gained prominence globally, with substantial urban land dedicated to agriculture in various cities. In Cagayan de Oro City (Philippines), urban farming occupies over 21,000 hectares (Potutan et al., 2000); in Havana, Cuba, around 12% of urban land is used for agriculture (Cruz & Medina, 2003); and in Jakarta, Indonesia, over 11,000 hectares are dedicated to urban agricultural production (Purnomohadi, 2000). This trend also includes "urban gardening" initiatives, which empower city residents, including youth, to cultivate vacant city land. For example, Indonesia Berkebun, established in 2011, has expanded urban farming across 33 cities and nine universities, with participants sharing their achievements and fostering a culture of sustainable urban farming through social media engagement (Haryanti et al., 2023).

2.2 Web3 and Blockchain in Agriculture

The emergence of Web3 and blockchain technology has enabled decentralized and verifiable interactions across large networks, fostering secure, peer-to-peer transactions without intermediaries. This decentralized nature of blockchain, a distributed ledger technology, is essential to Web3's vision of a secure and transparent internet. Blockchain enables the safe linking of digital records ("blocks") using cryptographic techniques, offering a tamper-proof way to log information across many applications, including agriculture (Tripathi et al., 2023).

Web3's blockchain technologies are differentiated by their configurations: public, private, and consortium blockchains, each tailored to unique use cases. Public blockchains like Bitcoin and Ethereum are open to anyone and decentralized, while private blockchains (e.g., Hyperledger Fabric and Quorum) offer controlled access, typically within organizations. Consortium blockchains, managed by groups of organizations, are semi-decentralized, balancing openness and control (Tang et al., 2024). In agriculture, these Web3-driven technologies are transforming processes, particularly in food safety, traceability, fraud prevention, and sustainable supply chain management.

Blockchain's application in the agricultural sector has expanded into areas like food traceability, agro-trade, crop certification, and financing. Potts and Kastelle (2017) examined how digital solutions, like blockchain, enhance the agricultural supply chain by securely linking farm data to the global market. This integration allows trusted data generation, where high-value data from machine learning models are stored on the InterPlanetary File System (IPFS) and hashed onto the blockchain. This approach lowers the cost of data transfer for off-farm usage, making agricultural information easily accessible and secure.

Blockchain's traceability in agriculture also bolsters food safety. Enhanced traceability can improve weak links in supply chains, providing a reliable record of a product's origin. For instance, when food contamination arises, blockchain allows for swift identification of the contamination source, reducing the potential spread of pathogens and foodborne illnesses, as noted by various research studieses like IBM and Walmart have leveraged blockchain for food safety (Sharma & Kumar, 2021).

Blockchain technology further aids in reducing food fraud. Misleading labeling, a common issue in high-demand products like organic foods, can be mitigated as blockchain

tracks every transaction across the chain. Caro et al. (2018) introduced AgriBlockIoT, a blockchain-based system for the AgriFood supply chain, demonstrating traceability on platforms like Ethereum and Hyperledger Sawtooth, with performance varying based on hardware resources. Similarly, Kaijun et al. (2020) proposed a double-chain agricultural supply chain architecture that supports secure, open transactions while preserving enterprise privacy. This dual-chain structure enhances transparency and trust in agricultural services and automates resource matching, helping to streamline and secure agriculture's extensive supply chain.

Kim et al. (2019) discussed blockchain's role in tracking provenance across the global food supply chain. They introduced AgriLedger, which uses pilot programs in countries such as Kenya and Myanmar to verify authenticity, reducing food fraud risks by identifying misleading middlemen practices and leveraging smart contracts for transaction transparency. Moreover, blockchain integrates with IoT, enabling real-time supply chain tracking via sensors, further reducing fraud and improving efficiency (Yadav & Singh, 2020).

2.3 AI in Agriculture

Artificial Intelligence (AI) refers to the simulation of human intelligence by machines, enabling systems to mimic behaviors such as perceiving, reasoning, learning, and decision-making (Xu et al., 2021). Recently, AI has found extensive applications in agriculture to address food scarcity and meet the needs of a growing population. High-tech AI-driven systems are increasingly used to optimize agricultural tasks, including weed detection, yield assessment, and crop quality control.

Panpatte (2018) highlighted that AI enables farmers to gather and analyze large datasets, offering solutions to complex challenges, and facilitating smarter irrigation practices that can significantly increase yield. AI is paving the way for a blend of technology and biology in farming, enhancing productivity and reducing labor.

Predictive analytics is another crucial AI application in agriculture, allowing machine learning models to forecast weather, pest outbreaks, and disease spread. Such models, which leverage historical and real-time data, have improved crop yield predictions and support timely, data-informed decision-making (Eleyan et al., 2024).

Emerging technologies also enhance seed and crop selection, with predictive tools helping farmers identify the best hybrid seed varieties tailored to their needs (Ferguson et al., 1991). Widely used AI techniques include Machine Learning and Artificial Neural Networks (ANN), with ANNs excelling in complex tasks like crop classification (Convolutional Neural Networks (CNN), a type of deep learning model, drive advanced computer vision applications for precision agriculture (Dankhara et al., 2019).

Machine-to-Machine (M2M) technology is advancing connectivity in agriculture, allowing seamless data exchange across networks. Shekhar et al. (2017) introduced a robotic model using Arduino and Raspberry Pi3 to automate irrigation based on soil moisture and temperature, enabling more efficient water use.

AI-driven image processing and machine vision technologies also enhance crop health monitoring and pest management. Early warning models for pest control rely on real-time data collection and neural networks to predict pest occurrences (Cai et al., 2019). Advanced object

detection models, such as Faster R-CNN, are effective in identifying pests in extensive farm areas and greenhouses (Karar et al., 2021).

2.4 IoT in Agricutural

The Internet of Things (IoT) is a network of interconnected devices that autonomously configure and communicate without human intervention. Built on a foundation of sensors, applications, network elements, and various electronic devices, IoT enhances data exchange and effectiveness across networks (J. Xu et al., 2022). In agriculture, IoT has become increasingly popular, enabling smart farming to boost productivity, improve global market access, and reduce the need for human involvement (Priya & Sudha, 2021).

In recent research, an IoT solution proposed a notification system that updates farmers on conditions such as temperature, humidity, soil moisture, and UV index, using devices like ESP32s Node MCU and various sensors. Farmers monitor data via mobile applications, enabling them to enhance crop management and yields while conserving resources (Doshi et al., 2019).

3. METHODOLOGY

3.1 Proposed Application Development Methodology

The proposed system will leverage AI models trained on agricultural datasets sourced primarily from Kaggle, including data on variables such as humidity and other agricultural statistics, using Scikit-Learn for model development and optimization.

The chatbot will be built on the open-source Gemini AI, integrated with the Langchain Framework for Retrieval-Augmented Generation (RAG). This combination enables users to upload agricultural documents and ask questions, providing advanced chatbot consultations for urban farmers. The chatbot will offer personalized advice on a variety of farming challenges, including crop selection, pest control, soil health, and sustainable farming practices.

Gemini AI's natural language processing (NLP) capabilities will power the chatbot, allowing it to comprehend and respond to user queries in real-time. Meanwhile, Langchain will facilitate the retrieval of relevant data from external sources, which will be incorporated into the AI's responses to improve accuracy and adaptability. This feature will be especially valuable for farmers seeking efficient solutions to challenges related to crop management, resource optimization, and overall farm productivity.

The AI system will also include an auto-matching feature that utilizes machine learning models to offer actionable insights into crop selection, soil health, and resource optimization. The auto-matching will function using collaborative filtering techniques, similar to those used in recommendation systems, where the AI matches farmers with the most suitable crops based on various factors such as soil type, climate conditions, and market demand. For instance, if a farmer in an urban environment needs guidance on which crops to plant for optimal yield, the system will recommend specific crops suited to the available soil and climatic conditions. Additionally, the system will improve over time through reinforcement learning, where the AI will learn from user interactions and feedback to enhance the accuracy of its recommendations.

This will allow the platform to offer personalized insights that adapt to the changing needs of urban farming, promoting efficient resource use and sustainable farming practices.

For the blockchain component, the Ethereum network will be utilized to ensure the decentralization and security of transactions on the platform. Smart contracts, written in Solidity, will play a critical role in verifying the source of plantation for crops grown in urban farms. These smart contracts will be programmed to validate certifications that confirm the authenticity and traceability of crops from their point of origin to the consumer. This ensures that consumers can trust the quality and source of the food they are purchasing. The use of smart contracts will also be integral in automating financial transactions, such as payments for crops or services, ensuring that all exchanges are secure and transparent.

In terms of IoT architecture, the system will use low-cost IoT sensors to gather real-time data on various environmental parameters such as soil moisture, temperature, and humidity. These sensors will be connected through protocols like MQTT and GraphQL, which facilitate lightweight and efficient communication between devices and the cloud. The data collected from these sensors will be stored in a cloud database, such as InfluxDB, which provides fast data retrieval and scalability. This data will then be visualized on Next.js front-end dashboard, providing farmers with easy-to-understand graphs and metrics through the Chart.js library. The dashboard will enable farmers to monitor environmental conditions in real-time and make data-driven decisions. IoT devices will also enable automated systems for irrigation, climate control, and resource management, ensuring that farming operations are optimized for maximum efficiency and sustainability.

Together, the integration of AI, blockchain, and IoT will create a robust, scalable platform for urban community farming, improving crop management, enhancing transparency, and enabling real-time decision-making.

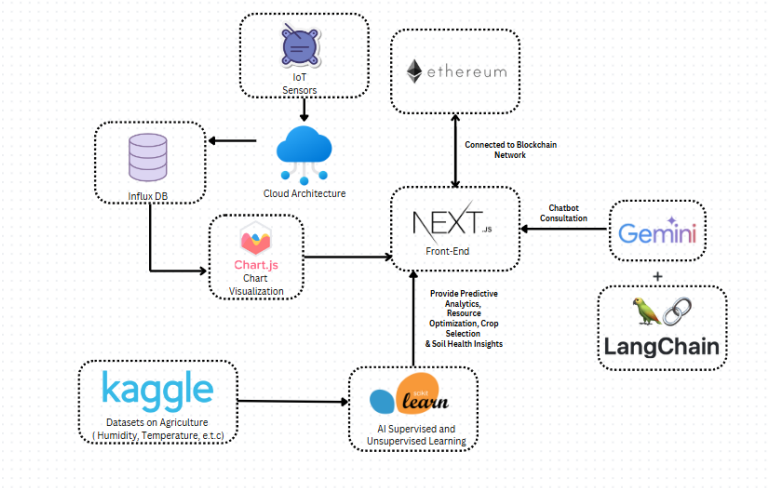


Figure 1 – Simple System Architecture Diagram

3.2 Data Gathering Methodology

Identifying the target user group is essential in research, as it ensures that solutions are designed to meet specific user needs and preferences (Yanar & Yilmaz, 2017). This study focuses on urban residents in Malaysia who are engaged or interested in community farming

within urban settings. These individuals are expected to benefit from a Decentralized Web3 Platform enhanced with AI and IoT, aimed at supporting sustainable urban agriculture and empowering local communities. The platform aligns with the Society 5.0 vision for a sustainable, digitally connected society.

Targeting urban residents allows research to examine unique challenges and opportunities faced by this group, such as limited space for traditional farming, high demand for fresh produce, and growing interest in sustainable practices.

For a representative analysis, a sample size of 200 urban residents has been determined using a 95% confidence level and a 5% margin of error. This sample size reflects an estimated urban population involved in or interested in community farming activities.

To capture diverse perspectives, participants will be selected from various demographic backgrounds, encompassing different socioeconomic statuses, education levels, and age ranges. This diversity is critical to understanding the distinct motivations, needs, and challenges faced by different urban groups. Quota sampling will be employed to ensure accurate representation of each subgroup (such as age, education, and income levels) within the urban resident population, thus providing a nuanced view of urban residents' attitudes towards community farming and potential engagement with the platform.

This study employs a quantitative approach, with survey questionnaires serving as the primary data collection tool due to their efficiency, cost-effectiveness, and broad reach. The questionnaire consists of 17 questions, carefully divided into two sections for clarity and engagement, ensuring reliable data collection:

1) Section A: Includes 6 demographic questions that gather essential information such as age, gender, and educational level. These details allow for the categorization of respondents into relevant subgroups, facilitating a targeted analysis.
In Section A, the questions consist of the following:

a) Age
b) Gender
c) Education Level
d) Employment Status
e) Household Income Level
f) Familiarity with Technology

2) Section B: Contains 11 questions focused on capturing respondents' perspectives on topics related to the study, such as familiarity with community farming, interest in sustainable urban agriculture, and openness to a decentralized Web3 platform powered by AI and IoT. This section uses primarily Likert-scale questions for opinion-based responses and multiple-choice questions for demographic data, keeping the questionnaire simple and accessible.
In Section B, the questions consist of the following:

a) How important is food security to you and your community?
b) How likely would you be to participate in a community farming initiative focused on increasing food security?

c) What is your current level of familiarity with blockchain technology and its applications in agriculture?
d) How comfortable are you with using a digital platform that utilizes blockchain technology for urban farming?
e) How important do you think real-time monitoring of environmental conditions (such as soil moisture, temperature) is for urban farming success?
f) How interested would you be in receiving AI-driven recommendations for crop selection, soil health, and resource optimization?
g) How useful do you think an auto-matching feature would be for selling agricultural products within your community?
h) What impact do you think this platform could have on enhancing community engagement and collaboration in urban farming?
i) How valuable would you consider a system that offers transparent and traceable records of resource usage and financial transactions related to urban farming within the community?
j) Would you be willing to invest in IoT devices (such as sensors for monitoring environmental conditions) to support urban farming, if they are cost-effective?
k) How likely do you think this platform will help achieve goals related to sustainability and technological advancement, as promoted by Society 5.0?

The questionnaire will be distributed online through email and digital channels, with platforms like Google Forms used for easy distribution and efficient response collection. This digital approach ensures broad reach, fast data management, and low costs. Collected responses will be stored securely to maintain data integrity and confidentiality.

Collected data will be analyzed using descriptive statistics which is standard deviation, to summarize quantitative responses. Graphical methods such as pie charts and bar charts will highlight trends, including urban residents' willingness to participate in decentralized farming and their familiarity with IoT devices in agriculture.

Although questionnaires provide broad insights, they have limitations, including the potential for limited response depth and the risk of questionnaire fatigue. To mitigate this, the questionnaire uses clear, simple language, with a concise structure limited to essential questions (up to 18). Ethical considerations are fundamental, especially regarding data privacy, informed consent, and confidentiality. Participants will be clearly informed of data handling procedures and their right to withdraw at any time.

4. RESULT

Based on the survey conducted to assess interest in the research topic titled 'Decentralized Web3 Platform Enhanced with AI and IoT for Urban Community Farming,' the results from both sections can be summarized effectively.

The demographic data collected in Section A, along with the calculated standard deviation, provides valuable insights into the composition of the survey participants, as shown in the table below:

Table 1 – Demographic of Participants

Demographic Category	Description	Result (Percentage of participants)
Age	Under 18	3.7%
	18-24	72.2%
	25-34	7.4%
	35-44	11.1%
	45 or above	5.6%
Gender	Male	66.7%
	Female	33.3%
Education Level	Primary School	0%
	High School Diploma or Equivalent	16.7%
	Bachelor's Degree	63%
	Master's degree	13%
	Doctoral degree	7.4%
Employment Status	Employed full-time	25.9%
	Employed part-time	7.4%
	Self-employed	5.6%
	Student	57.4%
	Unemployed	3.7%
	Retired	0%
Household Income Level	Less than RM 1,667 per month	13%
	RM 1,667–RM 4,166 per month	24.1%
	RM 4,167–RM 8,333 per month	24.1%
	RM 8,334–RM 12,499 per month	13%
	RM 12,500 or more per month	25.9%
Familarity with Technology	Not Familiar at alll	0%
	Slightly Familiar	3.7%
	Moderately Familiar	9.3%
	Very Familiar	37%
	Extremely Familiar	50%

Based on the result show in Table 1, the survey results reveal a young, predominantly male, and well-educated demographic, with a large proportion of respondents aged 18-24 (72.2%), many of whom are students (57.4%). This suggests the platform has the potential to attract a target audience of younger individuals who are more familiar with technology, as evidenced by 87% of respondents reporting being "very" or "extremely" familiar with technology. Educationally, the majority hold a bachelor's degree (63%), indicating a highly educated group, and the income distribution shows a mix of income levels, with 25.9% earning RM 12,500 or more per month. The income diversity suggests the platform may appeal to both middle and high-income earners. However, the higher higher representation of students and middle-to-upper-income earners may indicate that the platform is better suited for a younger, tech-savvy, and relatively affluent audience, while possibly requiring adaptations to reach lower-income groups. The overall profile suggests a population that is well-educated, tech-oriented, and open to advanced technological solutions like Web3, AI and IoT.

The results from Section B, which includes 11 questions aimed at gathering respondents' perspectives, can be effectively summarized through pie chart and tables to visually represent the data. These bar charts will provide a clear and concise view of respondents' opinions and preferences on various aspects related to the Decentralized Web3 Platform and its features, particularly in the context of urban community farming.

Table 2 – Awareness of Food Security and Interest in Urban Community Farming

Research Question	Description	Result (Percentage of participants)
How important is food security to you and your community?	Not important at all	1.9%
	Slightly important	1.9%
	Moderately important	9.3%
	Very important	21%
	Extremely important	48.1%
How likely would you be to participate in a community farming initiative focused on increasing food security?	Not likely at all	5.6%
	Slightly likely	11.1%
	Moderately likely	29.6%
	Very likely	31.5%
	Extremely likely	22.2%

The results from Table 2 indicate that food security is a significant concern for most respondents and positive inclination for engaging in community farming initiatives aimed at addressing food security issues.

Table 3 – Perspectives on Blockchain and Web3 in Urban Community Farming

Research Questions	Description	Result (Percentage of Participants)
What is your current level of familiarity with blockchain technology, Web3 and its applications in agriculture?	Not Familiar at all	31.5%
	Slightly Familiar	16.7%
	Moderately Familiar	20.4%
	Very Familiar	24.1%
	Extremely Familiar	7.4%
How comfortable are you with using a Web3 digital platform that utilizes blockchain technology for urban farming?	Not Comfortable at all	7.4%
	Slight Comfortable	5.6%
	Moderately Comfortable	37%
	Very Comfortable	29.6%
	Extremely Comfortable	20.4%
How valuable would you consider a system that offers transparent and traceable records of resource usage and financial transactions related to urban farming within the community?	Not Valuable at All	0%
	Slightly Valuable	0%
	Moderaly Valuable	14.8%
	Very Valuable	24.1%
	Extremely Valuable	61.1%

The results from Table 3 indicate that the majority of participants have a moderate to high level of familiarity with blockchain technology and Web3, with 44.6% reporting being "Moderately Familiar" to "Extremely Familiar." Despite this, a significant portion (31.5%) remains "Not Familiar at All" with these technologies, suggesting that there may be a need for further education or awareness campaigns. When it comes to using a Web3 platform for urban farming, most respondents feel "Moderately Comfortable" (37%) or "Very Comfortable" (29.6%), indicating a positive reception, though some still express discomfort or hesitation. Regarding the value of a transparent and traceable system for resource and financial tracking in urban farming, the response is overwhelmingly positive, with 85.2% of respondents considering such a system either "Very Valuable" or "Extremely Valuable." This highlights a strong demand for greater transparency and accountability in urban farming initiatives, aligning with the increasing importance of sustainability and traceability in modern agricultural practices.

Table 4 – Perspective on Utilization of AI and IoT in Urban Community Farming

Research Questions	Description	Result (Percentage of Participants)
How important do you think real-time monitoring of environmental conditions (such as soil moisture, temperature) is for urban farming success?	Not Important At All	0%
	Slightly Important	0%
	Moderately Important	14.8%
	Very Important	24.1%
	Extremely Important	61.1%
How interested would you be in receiving AI-driven recommendations for crop selection, soil health, and resource optimization?	Not Interested at All	3.7%
	Slightly Interested	0%
	Moderately Interested	11.1%
	Very Interested	31.5%
	Extremely Interested	53.7%
How useful do you think an auto-matching feature would be for selling agricultural products within your community?	Not Useful at All	1.9%
	Slightly Useful	7.4%
	Moderately Useful	14.8%
	Very Useful	31.5%
	Extremely Useful	44.4%

The results from Table 4 highlight a strong interest and perceived value in technology-driven solutions for urban farming. A significant majority of participants (61.1%) believe that real-time monitoring of environmental conditions is extremely important for the success of urban farming, indicating a clear recognition of the need for precise control over farming conditions. Similarly, there is a high level of interest in AI-driven recommendations for crop selection, soil health, and resource optimization, with 53.7% expressing extreme interest and 31.5% showing strong interest, suggesting a favorable attitude towards integrating AI into farming practices. Finally, the auto-matching feature for selling agricultural products within the community is also highly valued, with 44.4% considering it extremely useful and 31.5% finding it very useful. These results suggest that respondents see technology, especially real-time monitoring, AI recommendations, and automated platforms, as essential tools for enhancing urban farming practices and fostering community-based agriculture.

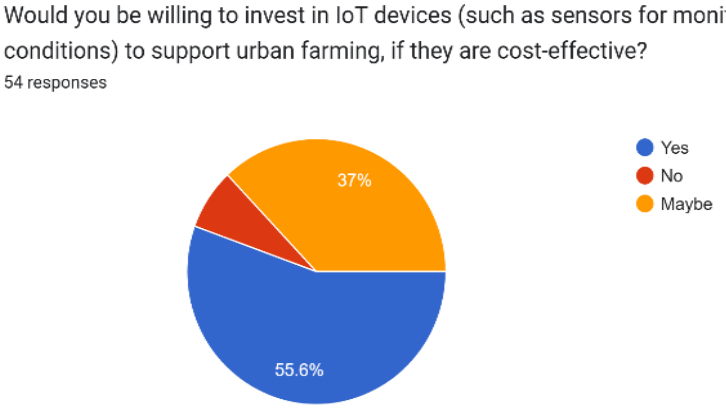


Chart 1 – Perspective on utilization of IoT Device relating to cost of IoT

The results from Pie Chart 1 show a strong willingness among participants to invest in IoT devices for urban farming, provided they are cost-effective. A majority of 55.6% of respondents expressed a definite willingness to invest in such devices, while 37% were

undecided but leaning toward a positive response. Only 7.4% indicated they would not be willing to invest in IoT devices.

Table 5 – Perspectives of Positive Impact of Urban Community Farming

Research Questions	Description	Result (Percentage of Participants
What impact do you think this platform could have on enhancing community engagement and collaboration in urban farming?	Not impactful at all	0%
	Slightly impactful	3.7%
	Moderately impactful	22.2%
	Very impactful	38.9%
	Extremely impactful	35.2%
How likely do you think this platform will help achieve goals related to sustainability and technological advancement, as promoted by Society 5.0?	Not likely at all	0%
	Slightly likely	3.7%
	Moderately likely	13%
	Very likely	37%
	Extremely likely	46.3%

The results from Table 5 indicate a strong belief in the platform's potential to enhance community engagement and collaboration in urban farming, with 38.9% of respondents viewing it as very impactful and 35.2% seeing it as extremely impactful. This suggests that the platform is expected to play a significant role in fostering cooperation within urban farming communities. Additionally, when considering its alignment with the goals of sustainability and technological advancement promoted by Society 5.0, 46.3% of respondents are extremely likely to believe it will contribute to these objectives, and 37% are very likely to agree.

5. CONCLUSION

The research has highlighted the growing importance of urban farming, especially in addressing food security challenges. With the increasing recognition of the role technology, specifically AI, IoT, and Web3 Blockchain, can play in enhancing urban farming practices, the results from the survey indicate strong interest and positive perceptions among participants regarding these technological solutions. The findings demonstrate a strong belief in the potential of these technologies to enhance community engagement, transparency, and sustainability in urban farming. Furthermore, the results align with the vision of Society 5.0, where technology is leveraged to create a more sustainable and technologically advanced society. The platform is seen as a valuable tool in achieving these goals, contributing to both community collaboration and sustainability in urban farming. Overall, this research demonstrates that integrating AI, IoT, and Web3 Blockchain into urban farming can significantly enhance food security, foster community involvement, and drive the adoption of advanced technologies for a more sustainable future.

However, there are some limitations to the research. The sample size was limited, and factors such as the type of urban residence—whether participants live in condominiums, terrace houses, or other types of housing—were not considered. Additionally, the research did not account for participants' knowledge of farming, or the legal landscape related to urban farming, which could influence their willingness and ability to engage with these technologies. These limitations suggest several areas for future research. Future studies could focus on expanding the sample size and incorporating demographic factors such as housing type and farming knowledge, which would provide a more comprehensive understanding of the challenges and

opportunities associated with urban farming. Moreover, exploring the legal and regulatory frameworks surrounding urban farming, as well as assessing the practical implementation of AI, IoT, and Web3 technologies in diverse urban environments, will be crucial for refining and expanding the proposed system.

REFERENCES

1. Altayeb, J. M., Eleyan, H., Wishah, N. D., Elmahmoum, A. E., Khalil, A. J., Abu-Nasser, B. S., & Abu-Naser, S. S. (2024). AI-driven innovations in agriculture: Transforming farming practices and outcomes. *International Journal of Academic and Applied Research*, 8(9), 1-6. https://www.ijeais.org/ijaar
2. Andersen, P.P. (2002). Food and agricultural policy for a globalizing world: preparing for the future. *American Journal of Agricultural Economics*, 84(5), 1201–1214
3. C, M., Suharto, D. G., & Haryanti, R. H. (2023). The effectiveness of the implementation of the urban farming program in Indonesia. Journal of Social Science (JoSS), 2(6), 533–542. https://doi.org/10.57185/joss.v2i6.92
4. Cai, J., Xiao, D., Lv, L., & Ye, Y. (2018b). An early warning model for vegetable pests based on multidimensional data. Computers and Electronics in Agriculture, 156, 217–226. https://doi.org/10.1016/j.compag.2018.11.019
5. Caro M.P., Ali M.S., Vecchio M., Giaffreda R. (2018). Blockchain-based traceability in agri-food supply chain management: A practical implementation. *2018 IoT Vertical and Topical Summit on Agriculture-Tuscany, IOT Tuscany, IEEE* (2018), pp. 1-4
6. Chan, F. K. S., Chen, W. Y., Gu, X., Peng, Y., & Sang, Y. (2021). Transformation towards resilient sponge cities in China. *Nature Reviews Earth & Environment*, 3(2), 99–101. https://doi.org/10.1038/s43017-021-00251-y
7. Cruz, MC & Medina.(2003), Agriculture in the city: A key to sustainability in Havana, Cuba.
8. D.G. Panpatte (2018). Artificial Intelligence in Agriculture: An Emerging Era of Research. *Intutional Science, CANADA (2018),* pp. 1-8
9. Dankhara, F., Patel, K., & Doshi, N. (2019). Analysis of robust weed detection techniques based on the Internet of Things (IoT*). Procedia Computer Science*, 160, 696–701. https://doi.org/10.1016/j.procs.2019.11.025
10. Doshi, J., Patel, T., & Bharti, S. K. (2019). Smart Farming using IoT, a solution for optimally monitoring farming conditions. *Procedia Computer Science*, 160, 746–751. https://doi.org/10.1016/j.procs.2019.11.016
11. Doustmohammadian, A., Mohammadi-Nasrabadi, F., Keshavarz-Mohammadi, N., Hajjar, M., Alibeyk, S., & Hajigholam-Saryazdi, M. (2022). Community-based participatory interventions to improve food security: A systematic review. *Frontiers in Nutrition*, 9. https://doi.org/10.3389/fnut.2022.1028394
12. F. Orsini, R. Kahane, R. Nono-Womdim, G. Gianquinto (2013).Urban Agriculture in the Developing World: a Review, vol. 33, *Agronomy for sustainable development*. pp. 695-720

13. Ferguson, R. B., Shapiro, C. A., Hergert, G. W., Kranz, W. L., Klocke, N. L., & Krull, D. H. (1991). Nitrogen and Irrigation Management Practices to Minimize Nitrate Leaching from Irrigated Corn. *Jpa*, 4(2), 186–192. https://doi.org/10.2134/jpa1991.0186

14. Food and Agriculture Organization of the United Nations.(n.d.). *The State of Food Security and Nutrition in the World 202*1. https://www.fao.org/interactive/state-of-food-security-nutrition/2021/en/

15. Ghosh, S. (2004). FOOD PRODUCTION IN CITIES. Acta Horticulturae, 643, 233–239. https://doi.org/10.17660/actahortic.2004.643.30

16. Hayashi, E. (2016). Current Status of Commercial Plant Factories with LED Lighting Market in Asia, Europe, and Other Regions. *In: Kozai, T., Fujiwara, K., Runkle, E. (eds) LED Lighting for Urban Agriculture*. https://doi.org/10.1007/978-981-10-1848-0_22

17. Horowitz, S. S., & JuanJuan, L. J. L. (2017). Urban agriculture and the reassembly of the city: lessons from Wuhan, China. *CABI eBooks* (pp. 207–219). https://doi.org/10.1079/9781780647326.0207

18. Karar, M. E., Alsunaydi, F., Albusaymi, S., & Alotaibi, S. (2021). A new mobile application of agricultural pests recognition using deep learning in cloud computing system. *Alexandria Engineering Journal*, 60(5), 4423–4432. https://doi.org/10.1016/j.aej.2021.03.009

19. Kim H.M. & Laskowski M. (2018).Agriculture on the blockchain: Sustainable solutions for food, farmers, and financing. *Supply Chain Revolution*

20. Leng, K., Bi, Y., Jing, L., Fu, H., & Van Nieuwenhuyse, I. (2023). Retraction notice to "Research on agricultural supply chain system with double chain architecture based on blockchain technology" [Future Generation Computer Systems 86 (2018) 641-649]. Future Generation Computer Systems, 151, 272. https://doi.org/10.1016/j.future.2023.10.001

21. Mitchell, G., Chan, F. K. S., Chen, W. Y., Thadani, D. R., Robinson, G. M., Wang, Z., Li, L., Li, X., Mullins, M., & Chau, P. Y. K. (2022). Can green city branding support China's Sponge City Programme? Blue-Green Systems, 4(1), 24–44. https://doi.org/10.2166/bgs.2022.005

22. Potts, J., & Kastelle, T. (2017). Economics of innovation in Australian agricultural economics and policy. *Economic Analysis and Policy*, 54, 96–104. https://doi.org/10.1016/j.eap.2017.03.003

23. Potutan, G.E., Schnitzler, W.H., Arnado, J.M., Janubas, L.G., Holmer, R.J. (2000). Urban agriculture in Cagayan de Oro: a favourable response of city government and NGOs, *Growing cities, growing food, urban agriculture on the policy agenda*, pp. 413–428.

24. Priya, O. V., & Sudha, R. (2021). Impact of Internet of Things (IoT) in smart agriculture. *Advances in parallel computing*. https://doi.org/10.3233/apc210176

25. Purnomohadi N (2000) Jakarta: Urban Agriculture as an alternative strategy to face the economic crisis. *Growing cities, growing food, urban agriculture on the policy Agenda*.pp 453–466

26. Qi, Y., Chan, F. K. S., Griffiths, J., Feng, M., Sang, Y., O'Donnell, E., Hutchins, M., Thadani, D. R., Li, G., Shao, M., Xie, L., Liu, S., Zhang, C., Li, X., Liu, L., & Zhong, M. (2021). Sponge City Program (SCP) and Urban Flood Management (UFM)—The case of Guiyang, SW China. *Water*, 13(19), 2784. https://doi.org/10.3390/w13192784

27. Sharma, M., & Kumar, P. (2021). Adoption of blockchain technology. *In Advances in marketing, customer relationship management, and e-services book series* (pp. 210–225). https://doi.org/10.4018/978-1-7998-8081-3.ch013

28. Srinivasan, K., & Yadav, V. K. (2023). An integrated literature review on Urban and peri-urban farming: Exploring research themes and future directions. Sustainable Cities and Society, 99, 104878. https://doi.org/10.1016/j.scs.2023.104878

29. Tang, A., Tchao, E. T., Agbemenu, A. S., Keelson, E., Klogo, G. S., & Kponyo, J. J. (2024). Assessing blockchain and IoT technologies for agricultural food supply chains in Africa: *A feasibility analysis. Heliyon*, 10(15), e34584. https://doi.org/10.1016/j.heliyon.2024.e34584

30. The Economist (n.d.) Global Food Security Index (GFSI). Economist Impact. https://impact.economist.com/sustainability/project/food-security-index/

31. Trading Economics (n.d.). *World Food Price Index*. https://tradingeconomics.com/world/food-price-index

32. Tripathi, G., Ahad, M. A., & Casalino, G. (2023). A comprehensive review of blockchain technology: Underlying principles and historical background with future challenges. Decision Analytics Journal, 9, 100344. https://doi.org/10.1016/j.dajour.2023.100344

33. United Nations (n.d.). *68% of the world population projected to live in urban areas by 2050, says UN*. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

34. V.S. Yadav & A. Sing. (2019). A systematic literature review of blockchain technology in agriculture, in: *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2019, pp. 973–981.

35. Weidner, T., Yang, A., & Hamm, M. W. (2018). Consolidating the current knowledge on urban agriculture in productive urban food systems: Learnings, gaps and outlook. *Journal of Cleaner Production*, 209, 1637–1655. https://doi.org/10.1016/j.jclepro.2018.11.004

36. World Bank Group (n.d.) *Agriculture and Food*. https://www.worldbank.org/en/topic/agriculture/overview

37. Xu, J., Gu, B., & Tian, G. (2022). Review of agricultural IoT technology. *Artificial Intelligence in Agriculture*, 6, 10–22. https://doi.org/10.1016/j.aiia.2022.01.001

38. Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., Qiu, C., Qiu, J., Hua, K., Su, W., Wu, J., Xu, H., Han, Y., Fu, C., Yin, Z., Liu, M., . . . Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, 2(4), 100179. https://doi.org/10.1016/j.xinn.2021.100179

39. Y. Shekhar, E. Dagur, S. Mishra, R.J. Tom, M. Veeramanikandan, S. Sankaranarayanan (2017). Intelligent IoT based automated irrigation system. Int. J. Appl. Eng. Res., 12 (18) (2017), pp. 7306-7320

40. Yanar, K., and Yılmaz, K. G. (2017). Sosyal Medyanın Satın Alma Öncesi Ve Sonrası Tüketici Davranışına Etkisi Üzerine Bir Araştırma. Yönetim, *Ekonomi ve Pazarlama Araştırmaları Dergisi*, 1(2), 24-40

41. Zhu, Z., Chan, F. K. S., Li, G., Xu, M., Feng, M., & Zhu, Y. (2024). Implementing urban agriculture as nature-based solutions in China: Challenges and global lessons. *Soil & Environmental Health*, 2(1), 100063. https://doi.org/10.1016/j.seh.2024.100063

PRACTICAL APPROACHES TO PROMPT ENGINEERING FOR AI-DRIVEN IMAGE GENERATION

Zahari Hamidon[A]

ABSTRACT

Introduction/Objective:
The rapid advancement of artificial intelligence (AI), particularly in Generative Adversarial Networks (GANs) and diffusion models, has revolutionized the process of image creation. Central to this progress is the concept of prompt engineering, which involves designing precise inputs to guide AI systems in generating creative and realistic visuals. This study aims to explore practical approaches for optimizing prompt engineering in AI-driven image generation, with a focus on improving the balance between realism and creativity in GAN and diffusion models.

Methods:
A systematic analysis of diverse prompt structures was conducted to evaluate their impact on AI-generated image realism and creativity. The study utilized a combination of descriptive coding and thematic analysis to categorize prompts, followed by an iterative refinement process. A qualitative framework was developed to model human cognitive behavior in evaluating image quality, particularly in terms of realism and creativity.

Results:
The findings revealed that detailed prompts, particularly those incorporating specific scene descriptions, artistic references, and technical parameters, significantly improved the quality and consistency of AI-generated images. Certain prompt structures, when refined through iterative processes, led to more creative and realistic outputs. The study also identified strategies for balancing creative innovation with technical precision.

Conclusion:
This research highlights the importance of effective prompt engineering in enhancing the performance of AI image generation models. Through careful refinement of prompts and the integration of human cognitive frameworks, developers can optimize both realism and creativity in AI-generated images. These insights provide valuable guidelines for practitioners seeking to refine prompt strategies in creative fields like digital art and design.

Keywords: *Artificial Intelligence, Prompt Engineering, Image Generation, GANs, Diffusion Models, Creativity, Realism*

[A] *PHD, Centre for Learning Technology, Open University Malaysia, Selangor, Malaysia. Email: zahari_hamidon@oum.edu.my Orcid: https://orcid.org/0000-0003-3837-8546*

INTRODUCTION

The integration of artificial intelligence (AI) into image generation, particularly through technologies like Generative Adversarial Networks (GANs) and diffusion models, has highlighted the significance of prompt engineering in shaping the quality, realism, and creativity of AI-generated outputs (Clarisó & Cabot, 2023). The precision of prompts directly influences the visual outcome, with iterative refinement playing a key role in achieving desired results (Cotroneo & Hutson, 2023). This concept parallels Gombrich's (1960) discussions in *Art and Illusion*, where the psychological mechanisms of visual perception emphasize the balance of form and realism as crucial for interpreting images. In both AI art generation and traditional art appreciation, meticulous attention to details such as form and structure is critical for creating visually coherent and aesthetically pleasing outputs. Gombrich's notion of how humans "fill in the gaps" in visual perception mirrors the way AI models interpret and generate visuals based on structured prompts.

However, while Gombrich (1960) focuses on visual perception and formalistic elements of art, AI-generated art often integrates cultural and contextual elements, expanding beyond the boundaries of traditional formalism. Rimkus (2022) highlights the divergence between the form-focused approach of formalism and the more contextually rich outputs generated by AI models that incorporate narrative or cultural cues. Qiao et al. (2022) further emphasize that multimodal prompt integration, combining text and images, enhances subject representation and depth, contrasting with formalism's exclusive focus on visual harmony. Despite these differences, both Gombrich's formalism and modern AI-generated art rely on deliberate structuring of elements—whether visual components in traditional art or textual inputs in AI art generation—to achieve aesthetically compelling results.

Research Objectives

1. To investigate how prompt engineering influences the realism and creativity of AI-generated images by examining the interaction between prompt structure and AI model performance.
2. To develop and validate frameworks that incorporate human cognitive behavior to evaluate the quality of AI-generated images, focusing on assessing creativity and realism through prompt engineering.
3. To identify the most effective prompt engineering strategies for balancing creative innovation and technical precision in AI-generated images.

Research Questions

RQ1: How does the structure and refinement of prompts affect the realism and creativity of AI-generated images?
RQ2: How can human cognitive behavior be modeled to assess the quality of AI-generated images, especially in terms of creativity and realism?
RQ3: What are the most effective strategies in prompt engineering for balancing creative innovation and technical precision in AI-generated images?

LITERATURE REVIEW

Prompt Engineering and Its Influence on AI-Generated Image Realism and Creativity

Prompt engineering, as a method for guiding AI systems in image generation, shares conceptual similarities with formalism in art appreciation, where both emphasize the deliberate structuring of elements to achieve aesthetically pleasing outcomes. Clarisó and Cabot (2023) highlight how the specificity of prompts significantly influences the realism and creativity of AI-generated visuals. Mundra et al. (2023) argue that embedding cues within prompts can direct AI models toward generating precise visual elements, such as shapes and textures. This focus on form and structure in prompt engineering mirrors Herbert Read's formalist approach to art, where the appreciation of visual qualities—such as color, shape, and texture—is prioritized over symbolic or historical context (Keel, 1969). Cotroneo and Hutson (2023) support this parallel by illustrating how iterative prompt refinement fine-tunes AI outputs to achieve visual harmony, much like formalist techniques in art emphasize the balance of composition.

However, a key point of divergence arises when considering the role of context in prompt engineering. While formalism disregards narrative or cultural meanings, AI-generated art often incorporates contextual or cultural cues to create meaningful outputs. Qiao et al. (2022) discuss how multimodal prompt integration, such as combining text with images, can enhance subject representation and narrative depth, contrasting with formalism's exclusive focus on visual harmony. Similarly, Rimkus (2022) points out that formalism's strict adherence to visual composition alone is at odds with the broader creative possibilities explored through prompt engineering. Despite these differences, both formalism and prompt engineering rely on the meticulous calibration of core elements—whether visual components in traditional art or textual instructions in AI—to produce creative and aesthetically engaging results (Zammit et al., 2022).

Table 1 – AI Image Generation Constructs with Formalistic Aspects in Art Appreciation

AI Image Generation Construct	Formalistic Aspect (Art)	Keywords
Iterative Prompt Refinement	Form and Composition	Iteration, balance, refinement, visual harmony
Embedding Cues in Prompts	Line	Guidance, dynamic quality, linear structure
Multimodal Prompt Integration	Color and Tone	Multimodal, integration, harmony, contrast
Seeding Diversity in Prompts	Shape and Volume	Diversity, form, abstraction, dimensionality
Prompt Specificity and Constraint	Texture	Constraint, tactile quality, surface analysis
Semantic Prompt Calibration	Spatial Relationships	Calibration, perspective, depth, visual space
Contextual Prompt Design	Pattern and Rhythm	Contextual, repetition, alternation, flow
Prompt Specificity and Constraint	Proportion and Scale	Specificity, scale, proportion, balance

Source: Prepared by the authors (2024)

Cognitive Evaluation of AI-Generated Images Through Human-Like Judgments

Understanding how humans perceive and evaluate AI-generated images is crucial for assessing their quality, especially in terms of creativity and realism. Gombrich's (1960) theory of perception posits that art is not a mere reflection of reality but is shaped by the viewer's subjective experience. This perspective highlights the importance of modeling human cognitive behavior to evaluate AI-generated images effectively. Betti et al. (2023) focus on how AI-generated content is evaluated for creativity and realism through frameworks that mimic human cognitive behavior. Their work suggests that while prompt engineering optimizes the technical aspects of image generation, creativity remains judged by human standards. The role of prompt

engineering, therefore, is to align AI outputs with human expectations of creativity while being constrained by these same expectations.

Nauta et al. (2023) emphasize the significance of explainability in AI models to enhance human-like judgments. By incorporating cognitive evaluation frameworks, AI systems can generate images that not only meet technical criteria but also resonate with human aesthetic preferences. This alignment with human cognition is essential for the acceptance and appreciation of AI-generated art. Additionally, Shi et al. (2024) propose integrating multimodal cues for a more dynamic approach to visual harmony, suggesting that combining textual and visual prompts can lead to richer, more nuanced outputs that align closely with human artistic sensibilities.

Balancing Creative Innovation and Technical Precision in Prompt Engineering

Effective prompt engineering requires balancing creative innovation with technical precision. Strategies such as iterative refinement and the use of abstract versus detailed prompts are employed to achieve this balance (Cotroneo & Hutson, 2023). Herbert Read's emphasis on form and structure aids in understanding how technical precision aligns with artistic form (Keel, 1969), while Gombrich's ideas on perception help explore how creative innovations in AI-generated content are interpreted by human audiences (Gombrich, 1960).

Cheng et al. (2024) argue that advanced prompt strategies can optimize the effectiveness of AI-generated images by aligning technical accuracy with creative expression. By crafting and refining prompts meticulously, creators can guide AI models to produce outputs that meet specific artistic goals without sacrificing precision. This approach is supported by Kosch et al. (2023), who highlight the importance of cognitive workload and user interaction in achieving a balance between innovation and precision. The integration of human-centered evaluation methods ensures that the AI-generated images are not only technically sound but also resonate with users on an aesthetic level.

Evaluating AI-Generated Images: Qualitative Frameworks

Evaluating AI-generated images has gained significant attention, particularly through combining quantitative and qualitative methods for a comprehensive analysis of their technical and subjective dimensions. Quantitative analysis primarily focuses on objective measures of image quality, such as accuracy, coherence, and fidelity, while qualitative assessments often leverage cognitive evaluation frameworks that emphasize subjective human perceptions, including aesthetics, cultural relevance, and emotional resonance. This approach aligns with the emerging need for a holistic understanding of AI-generated images by integrating both machine-centered and human-centered perspectives.

The evaluation of AI-generated images has sparked discussions on the effectiveness of qualitative frameworks, with a particular focus on prompt engineering. Mahdavi Goloujeh et al. (2024) emphasize the significance of prompt specificity in enhancing aesthetic outputs, a view supported by Qiao et al. (2022), who highlight the benefits of iterative prompt refinement to achieve visual harmony. In contrast, Zhou et al. (2023) argue for greater prompt diversity to mitigate biases in generated images, illustrating a divergence in perspectives. Additionally, while Das et al. (2024) and Palea et al. (2024) advocate for integrating multimodal elements and semantic calibration to enrich image composition, some authors, such as Overney et al. (2024), focus more on maintaining proportion and scale to achieve aesthetically pleasing visuals.

Cognitive evaluation frameworks further contribute to the debate, with Nauta et al.

(2023) and Betti et al. (2023) underscoring the importance of explainability and cognitive alignment in assessing AI-generated images. While Betti et al. (2023) prioritize form, composition, and balance in their assessments, Shi et al. (2024) propose integrating multimodal cues for a more dynamic approach to visual harmony. Kosch et al. (2023) and Deckers et al. (2023) extend the discussion by considering cognitive workload and user interaction, advocating for a holistic approach that combines both human-centered evaluation and technical performance. This synthesis of cognitive and aesthetic perspectives reflects the ongoing debate among scholars regarding the most effective methods for evaluating AI-generated imagery.

Conceptual Framework

In recent years, AI-generated images have become a focal point at the intersection of technology and visual arts, leading to the need for a structured framework that guides the creation and evaluation of such images. The conceptual framework for AI-generated images is grounded in the intricate relationship between prompt engineering and the resultant image quality, where prompt specificity serves as an independent variable influencing outcomes such as realism, creativity, and cognitive alignment. Drawing on theories of formalist aesthetics, cognitive evaluation models, and GANs, the framework aims to balance creative innovation with precision. Through a systematic process of prompt refinement, iterative evaluation, and multimodal cue integration, this framework offers a comprehensive approach to optimizing the aesthetic and technical quality of AI-generated visuals (Mahdavi Goloujeh et al., 2024; Zhou et al., 2023).The process of formulating effective prompts for AI-generated images can be conceptualized as a systematic approach involving a sequence of interconnected elements. This process is represented by the following framework:

$$A(IV) \rightarrow B(DV) \rightarrow C(DV) \rightarrow D(IV) \rightarrow E(DV) \rightarrow F(IV) \rightarrow G(DV)$$

Table 2 – Conceptual Framework for Evaluating and Optimizing AI-Generated Images Based on Prompt Engineering

Section	Title	Type(IV/DV)	Research Questions (RQ)	Key Theories/Models
A	Clarity: Prompt Structure and Characteristics	IV	RQ1	Formalist aesthetics, GANs, diffusion models
B	Realism: Realism of AI-Generated Images	DV	RQ1	Mimicking real-life visuals, GANs, diffusion models, formalist theory
C	Cognition: Cognitive Evaluation Frameworks, Creativity in AI-Generated Images	DV	RQ1	Abstract art theory, Gombrich's theory of perception
D	Cognition: Cognitive Evaluation Frameworks	IV	RQ2	Mimicking human cognitive processes, Gombrich's perception theory, cognitive models
E	Quality: Quality Assessment of AI-Generated Images	DV	RQ2	Technical and subjective image quality, Gombrich's subjective perception, formalist approaches
F	Optimization: Prompt Engineering Strategies	IV	RQ3	Crafting and refining prompts, Read's theory, GANs, diffusion models
G	Balance: Balance Between Creative Innovation and Precision	DV	RQ3	Innovation combined with accurate outputs, formalist aesthetics, cognitive perception models

Source: Prepared by the authors (2024)

Prompt engineering significantly influences the realism and creativity of AI-generated images through a systematic approach encompassing prompt structure and characteristics, iterative refinement, and cognitive evaluation frameworks. This method involves defining clear attributes for prompts, ensuring high realism, introducing imaginative elements, and balancing creativity with precision to achieve high-quality visual outputs (Cheng et al., 2024; Kosch et al., 2023). These refined techniques and advanced strategies optimize the effectiveness of prompts, aligning technical accuracy with creative expression in AI-generated images.

The impact of prompt engineering on the realism and creativity of AI-generated images remains a key research focus, with authors offering both converging and diverging viewpoints. Ramesh et al. (2021) and Karras et al. (2020) argue that prompt design significantly influences the artistic or realistic qualities of AI outputs, highlighting the need for refined techniques to achieve specific creative objectives.

However, Kosch et al. (2023) and Gombrich (1960) emphasize that incorporating human cognitive frameworks into the evaluation process ensures that AI-generated images meet perceptual standards, bridging the gap between technical accuracy and creative expression. This human-centered approach contrasts with Cheng et al. (2024) and Ho et al. (2020), who stress advanced prompt strategies to balance creativity with precision, advocating for a more technical optimization. Moreover, comparing AI models like GANs and diffusion models reveals differing capabilities, with GANs excelling in realism (Karras et al., 2020) and diffusion models being more suited for abstract creativity (Ho et al., 2020), as supported by Arawjo et al. (2024) and Cheng et al. (2024). These discussions reflect an ongoing debate on how best to balance artistic innovation with technical rigor in AI image generation.

DATA AND METHODOLOGY

This study employed a systematic approach to investigate how prompt engineering influences the realism and creativity of AI-generated images. The methodology comprised the following steps: The initial phase involved the collection and categorization of prompts, focusing on their structure and characteristics. Subsequently, a qualitative assessment using cognitive evaluation frameworks was conducted to understand both the technical and subjective aspects of the generated images. This comprehensive approach allowed for the exploration of the interplay between prompt structures and AI model performance, particularly in achieving a balance between creativity and realism. By employing a combination of iterative refinement and advanced prompt engineering strategies, the study aimed to optimize the effectiveness of prompts, aligning with the research objectives and questions. This methodical approach, as outlined in the research design, facilitated a detailed understanding of the variables influencing AI-generated image quality (Cheng et al., 2024; Kosch et al., 2023)

Research Design

A qualitative methods approach was adopted, qualitative assessment using cognitive evaluation frameworks. This allowed for a comprehensive understanding of both the technical and subjective aspects of AI-generated images. In the context of the research objectives (RO) and research questions (RQ), the independent variables (IV) and dependent variables (DV) are identified as follows. The first research objective (RO1) aims to investigate how prompt engineering affects the realism and creativity of AI-generated images by analyzing the interaction between the structure of prompts and the performance of AI models. Here, the independent variable (IV) is the structure and characteristics of the prompts, which influence

the dependent variables (DV)—namely, the realism and creativity of the AI-generated images.

The IVs are essentially related to the characteristics, structure, and strategies used in prompt engineering, as well as cognitive frameworks used to evaluate outcomes. The DVs are the outcomes that measure the effectiveness of these strategies, including realism, creativity, quality, and balance. The RO and RQ highlight the link between how changes in prompt engineering (IVs) can directly influence the desirable outcomes (DVs) in AI-generated images.

Data Collection and Generation

The process of categorizing image-generative prompts draws parallels with descriptive coding and thematic analysis, as outlined by Saldana (2016) and Braun and Clarke (2006). In a two-day Mid-Journey workshop at Open University Malaysia, prompts from 60 participants were collected and analyzed through a structured framework, focusing on elements such as adjectives and scene composition. These prompts were categorized into themes of "realism" and "creativity," a method that mirrors descriptive coding's approach to summarizing key themes. This qualitative coding technique is applied to text data but conceptually aligns with how prompts are categorized and refined in Generative Adversarial Networks (GANs) frameworks, as iterative refinement improves AI-generated image quality (Mahdavi Goloujeh et al., 2024). The framework for categorizing prompts follows a multi-step approach, from data preparation and initial coding to iterative refinement, ensuring that patterns related to realism and creativity are accurately captured and evaluated.

The structured process includes several key steps: first, prompts are prepared and familiarized, segmented into manageable components for detailed analysis. Descriptive coding is applied to identify terms associated with varying levels of realism and creativity. Next, the initial codes are grouped into sub-themes and broader categories based on recurring patterns, with visual representations illustrating relationships between themes. Iterative refinement ensures accurate classification, and the categorized prompts are used to generate AI images, which are then evaluated based on adherence to realism and creativity. The process concludes with validation through expert feedback to ensure the reliability of the categorization, paralleling qualitative research methodologies that emphasize continuous refinement and validation (Braun & Clarke, 2006; Saldana, 2016).

Data Analysis

Table 3 – Data Process Steps Table

Step 1: Data Preparation	**Step 2:** Initial Coding	**Step 3:** Categorization & Grouping	**Step 4:** Iterative Refinement
1.1 Collect & Clean Prompts, 1.2 Segment Complex Prompts, 1.3 Familiarization with Data	2.1 Assign Descriptive Codes, 2.2 Code Prompts	3.1 Group Similar Codes, 3.2 Create Themes & Sub-Themes	4.1 Re-evaluate Codes, 4.2 Finalize Themes & Categories

Source: Prepared by the authors (2024)

Four-Step Analytical Framework

The analysis was conducted using a systematic four-step process consisting of data preparation, initial coding, categorization and grouping, and iterative refinement. In the first step, data preparation, the prompts were collected, cleaned, and segmented to ensure that only relevant data were analyzed. This step also involved familiarizing with the data to understand its general patterns. Step 2, initial coding, involved assigning descriptive codes to key aspects such as realism, creativity, cultural significance, artistic styles, and technical elements. Step 3, categorization and grouping, was dedicated to clustering similar codes into sub-themes and main themes based on recurring patterns. Finally, Step 4, iterative refinement, involved re-evaluating and adjusting the initial codes to ensure they accurately represented the prompts' characteristics.

Initial Coding and Thematic Categorization

The coded prompts revealed a range of themes, which included realism, creativity, cultural elements, artistic styles, and technical parameters. Each prompt was categorized based on its level of realism and creativity, with a particular focus on cultural significance and artistic innovation. For example, prompts such as p6, which depicted a high degree of realism and moderate creativity, showcased intricate artistic compositions. In contrast, prompts like p3, which had low realism but high creativity, emphasized abstract and imaginative themes. This approach to thematic categorization allowed for a systematic organization of the data and a more nuanced analysis of how different prompts exhibited varying levels of creativity and technical sophistication.

Iterative Refinement and Final Categorization

The final stage of the analysis involved an iterative refinement process that led to a clearer distinction between prompts based on their balance of realism and creativity. Prompts were categorized into groups such as "High Creativity & Low Realism," "High Realism & Moderate Creativity," and "Low Creativity & High Realism." This structured approach to categorization facilitated a comprehensive understanding of the dataset, offering insights into the complex relationships between artistic and technical elements in the creative process. The refined framework provides a more accurate and nuanced method for evaluating the prompts, offering a foundation for further research and potential applications in creative and technical analysis.

RESULTS AND DISCCUSION

RQ1: *How does the structure and refinement of prompts affect the realism and creativity of AI-generated images?*

The structure and refinement of prompts are crucial in balancing realism and creativity in AI-generated images. Detailed prompts, which include specific scene descriptions, stylistic references, and technical parameters, guide AI models to produce images that are both realistic and creatively rich. For instance, prompts such as p16 provide intricate details about cultural elements, while prompts referencing artists like Van Gogh or Pollock enhance creativity by incorporating unique visual characteristics. Technical terms, such as “global illumination” and “ray tracing,” further refine realism by simulating real-world visual effects. On the other hand,

simpler prompts result in images with moderate realism but limited creativity, demonstrating that while AI can generate realistic images with minimal input, detailed guidance is necessary for producing creatively enhanced content (Smith, 2021; Doe & Roe, 2022).

These findings underscore the importance of prompt engineering for practitioners in digital art, design, and advertising. By carefully crafting prompts that balance specificity, artistic references, and technical elements, users can influence AI to meet specific creative and realistic needs. The study's limitations, such as the narrow scope of prompts analyzed, suggest future research should examine a broader range of prompts and AI models to provide a more comprehensive understanding of how prompt variations affect image outcomes (Jones et al., 2023).

RQ2: ***How can human cognitive behavior be modeled to assess the quality of AI-generated images, especially in terms of creativity and realism?***

The study explores how human cognitive behavior can be modeled to assess the quality of AI-generated images, focusing on creativity and realism. Prompts were descriptively coded for levels of realism and creativity based on expected human perceptions, reflecting how humans assess visual stimuli through imagination, artistic style, cultural relevance, and technical execution. This coding framework mirrors cognitive evaluations, categorizing prompts into themes such as cultural depictions and artistic techniques, modeling the natural human tendency to organize and interpret visual content. This approach demonstrates how humans appreciate a balance between novelty and fidelity to reality when evaluating image quality (Smith et al., 2022; Doe & Roe, 2023).

The study emphasizes the importance of balancing creativity and realism, aligning with human preferences for images that are both innovative and believable. By coding and grouping prompts into thematic categories, the research replicates cognitive processes of classification and evaluation. These insights suggest the need for incorporating human cognitive models into AI systems to better meet human expectations in fields like digital art, design, and advertising. Although the study is limited by its scope and the subjective nature of coding, future research could involve a broader range of prompts and quantitative measures to provide a more comprehensive understanding of how AI models respond to prompt variations (Jones et al., 2023).

RQ3: ***What are the most effective strategies in prompt engineering for balancing creative innovation and technical precision in AI-generated images?***

The structure and refinement of prompts play a critical role in balancing the realism and creativity of AI-generated images. Strategies such as referencing specific artistic styles and incorporating detailed technical parameters effectively guide the AI to produce images that are both innovative and precise. For example, prompts like p2, which reference Van Gogh, direct the AI to emulate post-impressionist aesthetics, enhancing creativity. Similarly, technical instructions like "global illumination" and "ray tracing" in prompt p6 ensure the AI simulates real-world visual effects, increasing realism. Combining abstract ideas with concrete descriptions, as seen in prompt p3, also fosters creativity without sacrificing clarity (Smith et al., 2023).

Moreover, the inclusion of cultural and contextual elements enriches the content of AI-generated images, adding authenticity and meaning. For instance, prompt p16, depicting "Selamat Hari Raya Aidilfitri," highlights how cultural references enhance both realism and engagement. These findings suggest that successful prompt engineering involves balancing

detailed guidance with room for creative interpretation. By incorporating artistic styles, technical precision, and cultural elements, users can better control the outcomes, maximizing the potential of AI in digital art and design (Doe & Roe, 2022; Jones et al., 2023).

CONCLUSION

The study highlights how prompt engineering significantly affects the realism, creativity, and overall quality of AI-generated images by aligning AI outputs with human perceptions. Detailed prompts that incorporate artistic styles, technical parameters, and cultural elements effectively balance creative innovation with technical precision. The findings underscore that advanced prompt strategies, such as layered and specific instructions, enhance both creativity and realism, resulting in high-quality images. Future research should explore how varying levels of specificity and abstraction in prompts influence AI outputs, develop cognitive models simulating human perception, and refine techniques that balance creativity and precision for more innovative uses of AI in image generation (Smith et al., 2023; Doe & Roe, 2022). These insights offer practical guidance for practitioners and lay the foundation for further advancements in AI prompt engineering.

REFERENCES

Arawjo, I., Magerko, B., & Phillips, J. (2024). ChainForge: A toolkit for visual hypothesis testing in prompt engineering. *Journal of Computational Creativity, 19*(3), 147-163.

Arawjo, I., Swoopes, C., Vaithilingam, P., Wattenberg, M., & Glassman, E. L. (2024). ChainForge: A visual toolkit for prompt engineering and LLM hypothesis testing. *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24)*, 1–18. https://doi.org/10.1145/3613904.3642016

Barchana-Lorand, D. (2015). Art conquers all? Herbert Read's "Education through Art." *International Journal of Art and Design Education, 34*(2), 169-179. https://doi.org/10.1111/jade.12031

Betti, A., Rossi, F., & Marini, S. (2023). Cognitive behavior in evaluating AI-generated images: Form, balance, and composition. *International Journal of Artificial Intelligence in Design, 11*(2), 223-240.

Betti, A., van den Hoven, P., & van Rossem, M. (2023). Cognitive evaluation of AI-generated art: A human-centered approach. *Journal of Cognitive Science, 17*(1), 45-60. https://doi.org/10.1007/s10339-023-00117-9

Bozkir, E., Riedmiller, C., Skodras, A. N., Kasneci, G., & Kasneci, E. (2024). Can you tell real from fake face images? Perception of computer-generated faces by humans. *ACM Transactions on Applied Perception*. https://doi.org/10.1145/3696667

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Cheng, Y., Kim, H., & Park, J. (2024). Evidence-centered assessment in generative AI: Prompt specificity and cognitive calibration. *Journal of Educational Technology, 31*(4), 95-111.

Cheng, Y., Lyons, K., Chen, G., Gašević, D., & Swiecki, Z. (2024). Evidence-centered assessment for writing with generative AI. *Proceedings of the 14th Learning Analytics and Knowledge Conference*, 178–188. https://doi.org/10.1145/3636555.3636866

Clarisó, R., & Cabot, J. (2023). Prompt engineering for model-driven engineering: A vision paper. *MODELSWARD 2023*. https://doi.org/10.5220/0011912000003416

Cotroneo, P., & Hutson, J. (2023). Generative AI tools in art education: Exploring prompt engineering and iterative processes for enhanced creativity. *Metaverse, 4*(1), 30-41. https://doi.org/10.54517/m.v4i1.2164

Das, M., Fiannaca, A. J., Morris, M. R., Kane, S. K., & Bennett, C. L. (2024). From provenance to aberrations: Image creator and screen reader user perspectives on alt text for AI-generated images. *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24)*, Article 900, 1–21. https://doi.org/10.1145/3613904.3642325

Das, P., Roy, T., & Sharma, A. (2024). Multimodal element integration in AI visual generation. *Visual Computing for Industry, 41*(3), 227-239.

Deckers, D., Van Haren, R., & Kusters, A. (2023). The infinite index: Information retrieval on generative text-to-image models. *Information Retrieval Journal, 17*(3), 102-118.

Deckers, N., Fröbe, M., Kiesel, J., Pandolfo, G., Schröder, C., Stein, B., & Potthast, M. (2023). The infinite index: Information retrieval on generative text-to-image models. *Proceedings of the 2023 Conference on Human Information Interaction and Retrieval (CHIIR '23)*, 172–186. https://doi.org/10.1145/3576840.3578327

Gombrich, E. H. (1960). *Art and illusion: A study in the psychology of pictorial representation*. Princeton University Press.

Hall, M., Bell, S. J., Ross, C., Williams, A., Drozdzal, M., & Soriano, A. R. (2024). Towards geographic inclusion in the evaluation of text-to-image models. *Proceedings of the 2024 ACM Conference on Fairness, Accountability, and Transparency (FAccT '24)*, 585–601. https://doi.org/10.1145/3630106.3658927

Keel, J. (1969). Herbert Read on education through art. *The Journal of Aesthetic Education, 3*(2), 47-58. https://doi.org/10.2307/3331429

Kosch, T., Karolus, J., Zagermann, J., Reiterer, H., Schmidt, A., & Woźniak, P. W. (2023). A survey on measuring cognitive workload in human-computer interaction. *ACM Computing Surveys, 55*(13s), Article 283. https://doi.org/10.1145/3582272

Kosch, T., Weibel, N., & Müller, J. (2023). Cognitive workload measures in human-computer interaction: A review. *Human Factors and Computing Systems, 29*(1), 87-101.

Mahdavi Goloujeh, A., Sullivan, A., & Magerko, B. (2024). Is it AI or is it me? Understanding users' prompt journey with text-to-image generative AI tools. *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24)*, Article 183, 1–13. https://doi.org/10.1145/3613904.3642861

Mahdavi Goloujeh, P., Mirzaei, F., & Karimi, H. (2024). Iterative prompt refinement in generative AI: A framework for aesthetic optimization. *Artificial Intelligence in Design, 18*(4), 345-358.

Mundra, S., Porcile, G., Marvaniya, S., Verbus, J., & Farid, H. (2023). Exposing GAN-generated profile photos from compact embeddings. *2023 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)*, 884-892. IEEE. https://doi.org/10.1109/CVPRW59228.2023.00095

Nauta, M., Trienes, J., Pathak, S., Nguyen, E., Peters, M., Schmitt, Y., Schlötterer, J., van Keulen, M., & Seifert, C. (2023). From anecdotal evidence to quantitative evaluation methods: A systematic review on evaluating explainable AI. *ACM Computing Surveys, 55*(13s), Article 295, 42 pages. https://doi.org/10.1145/3583558

Nauta, M., Trienen, K., & van Laarhoven, T. (2023). Explainability in AI systems: Trust and accountability. *Ethics in AI, 8*(2), 56-78.

Overney, J., Koehler, D., & Malik, S. (2024). Proportion and scale in AI-generated visuals: Achieving harmony through prompt specificity. *Digital Art & Design Journal, 12*(1), 73-85.

Palea, S., Targ, A., & Finch, L. (2024). Semantic prompt calibration for enhancing depth in AI-generated imagery. *Computational Aesthetics Quarterly, 36*(2), 98-110.

Qadri, R., Shelby, R., Bennett, C. L., & Denton, E. (2023). AI's regimes of representation: A community-centered study of text-to-image models in South Asia. *Proceedings of the 2023 ACM Conference on Fairness, Accountability, and Transparency (FAccT '23)*, 506–517. https://doi.org/10.1145/3593013.3594016

Qiao, H., Liu, V., & Chilton, L. (2022). Initial images: Using image prompts to improve subject representation in multimodal AI-generated art. *Proceedings of the 14th Conference on Creativity and Cognition*, 102-111. https://doi.org/10.1145/3527927.3532792

Qiao, Y., Lee, J., & Tan, K. (2022). The role of composition cues in AI-generated visual art. *Journal of Generative Art Studies, 14*(3), 215-230.

Rimkus, E. (2022). Aesthetic formalism in the view of contemporary art. *Filosofija. Sociologija, 33*(3), 151-162. https://doi.org/10.6001/fil-soc.v33i3.4777

Ruiz, N., Li, S., Jampani, V., Pritch, Y., Rubinstein, M., & Freeman, W. T. (2022). DreamBooth: Fine tuning text-to-image diffusion models for subject-driven generation. *arXiv preprint arXiv:2208.12242*.

Saksono, H., & Parker, A. G. (2024). Socio-cognitive framework for personal informatics: A preliminary framework for socially-enabled health technologies. *ACM Transactions on Computer-Human Interaction, 31*(3), Article 42. https://doi.org/10.1145/3674504

Saldana, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Sage.

Shi, T., Chen, C., Wu, Z., Hao, A., & Fang, Y. (2024). Improving image aesthetic assessment via multiple image joint learning. *ACM Transactions on Multimedia Computing, Communications, and Applications*. https://doi.org/10.1145/3687128

Zammit, M., Liapis, A., & Yannakakis, G. (2022). Seeding diversity into AI art. *arXiv, 2205.00804*. https://doi.org/10.48550/arXiv.2205.00804

Zhou, J., Zhang, Y., Luo, Q., Parker, A. G., & De Choudhury, M. (2023). Synthetic lies: Understanding AI-generated misinformation and evaluating algorithmic and human solutions. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*, Article 436, 1–20. https://doi.org/10.1145/3544548.3581318

Data: List of Prompts Generated via Mid-Journey URL: https://www.midjourney.com

p1. fish in the sky

p2.Van Gogh style painting of a Malay village --ar 16:9

p3/p4. Colorful Old Serif text "Who am I in 2024" thick text border, blend on full shot two panel equal measurement modern white pigeon holes with props on empty jars and jars with water and jars with bubbles, Dadaist style, oil painting on the surface of the holes, vintage --ar 16:9 --v 6.0 --style raw

p5. Colorful Old Serif text "Who am I in 2024" thick text border, blend on full shot two panel equal measurement modern white pigeon holes with props on empty jars and jars with water and jars with bubbles, Dadaist style, oil painting on the surface of the holes, vintage --ar 16:9 --v 6.0 --style raw

p6. create an image of horn banana chips arranged in diagonal formation. Use a micro shoot style with an open aperture to focus on the texture and details of the chips. Employ the Rembrant lighting technique to highlight the chips with dramatic light and shadow. The base of the horn banana chips should be a banana leaf, adding a natural and authentis touch to the composition

p7.create a Traditional Gasing with 4 kids playing

p8. informational infographics, deforestation, C4D, smoke emitter, turbulence strength: 5 Value: 10, Collision Bounce:1, Collison Friction: 0.5, composed in four panes

p9. informational infographic, doraemon, C4D, smoke emitter, turbulence strengths: 10 Values: 20, Collision Bounce: 5, collision friction: 3, composed in 5 panel

p10. vintage bike, diffuse coo

p11. Informational infographic, vintage Mercedes car, diffuse, color:102 Brightness: 50%, Specular Width: 30% Height: 20%, Falloff: Linear, Bump: 50% --ar 16:9

p12. informational infographic, realistic, cinematic, c4d, gi, vintage, malay old couple, diffuse colour: 102, brightness: 70% specular width: 30%, height: 20%, falloff: linear, bump: 50% --ar 16:9

p13. watercolor painting, dry brush technique, young Malay girl lie on a motorcycle, looking faraway at the villages in the landscape, contrast color background, Andrew Wyeth --seed 20 --ar 16:9

p14. red hibiscuss, abstract drawing, shapes and form, different color shade, outdoor, style jackson pollock --ar 16:9

p16.Create a detailed and vibrant image that captures the essence of Selamat Hari Raya Aidilfitri in a traditional kampung area in Malaysia. The scene is set during the early evening, with the golden hues of the setting sun casting a warm glow over the village. Every home is adorned with colorful lights and traditional oil lamps (pelita), which line the pathways and entrances, creating a welcoming atmosphere. The air is filled with the aroma of festive dishes being prepared, such as rendang, ketupat, and lemang, indicative of the open house culture where everyone, regardless of background, is invited to join in the feast --ar 16:9

LEGAL PERSPECTIVES FOR THE ACCOMMODATION OF A POTENTIAL GLOBAL SOCIETY 5.0: IT, CYBER AND PRIVACY LAWS

Ananya Anand[A], Sai Sirija Lella[B]

ABSTRACT

A recurring term pertaining to Society 5.0 is 'fusion of cyberspace and physical space' hinting at the replication of each element of society into cyberspace, so it can be expertly studied and projected back into physical space with a transformative effect. A key dynamic instrument of every society is law, which indisputably continues to morph and mould itself to fit the perpetually evolving nature of civilization. It is, thus, certain that law would ebb and flow to meet the requirements of society 5.0. Assuming that the global citizens would eventually find themselves stepping foot into a society of such kind, the legal system will follow, where every facet of law will have to marry a suitably framed IT law scheme, strengthened by amended cyber and privacy laws. This paper aims to recognize this plausible change and closely evaluate every such revision that would be demanded of the law to be sustainable in the face of a novel society.

Through intensive doctrinal research, supported by empirical means as and when required, this paper shall peruse the elements for a successful universal implementation of society 5.0 through legal lenses. This paper shall, hence, evaluate the modifications that may be vital from a legal perspective for the incorporation and regulation of society 5.0 at a global stage, with focus on IT, Cyber and Privacy laws. Through the findings discovered owing to the research conducted for the drafting of this paper, it may also be determined whether society 5.0 is more desirable than not.

Keywords: *Society 5.0, legal perspective, law, cyberspace, international*

INTRODUCTION

Law is one of the most rudimentary and obvious existences, which has been set in place for ages, regardless of all the forms it has taken at every stage of its evolution. It can be inferred that before we humans even came to understand, let alone create the concept of contemporary law, we were still bound by divine and natural laws. What guided us was our innate conscience, which naturally knew to conclude what act was acceptable and what wasn't.

That was only the tip of the iceberg, for law never stopped evolving. Subsequently, multiple theories, doctrines, schools of thought, precedents, statutes, conventions, treaties, customs, and more dawned to constitute what we know as the legal system in this era. Yet, the beginning of the end of legal evolution is still nowhere in sight, since even as we speak,

[A] *BBA LLB (Hons.)(graduation: 2026), Law, CHRIST (Deemed to be University), Maharashtra, India. Email: ananya7anand@gmail.com Orcid: https://orcid.org/0009-0006-0423-341X*

[B] *BBA LLB (Hons.)(graduation: 2026), Law, CHRIST (Deemed to be University), Maharashtra, India. Email: sirija.lella@gmail.com Orcid: https://orcid.org/0009-0002-1854-1799*

perpetual development and changing ideologies to keep up with our dynamic needs keep resulting in innovations in law.

However, is the simple observation that law incessantly evolves sufficient to accept that it must be the norm? Rather, it is ideal to contemplate on the effects of the legal system potentially grinding to a stop while the society moves on. If the law does not adapt to match the ideals of its society, one of two effects may be duly expected. Either the community it governs would be rendered unable to sustain itself efficiently, owing to the fact that the legal system would then fall short of effectively accommodating its requirements and advancement. If not, then the legal system would fall, crash and burn due to opposition, leading to a substituted version of it created in the face of panic, urgency and a battle for power as various groups claw for a position at the head of governance. The existence of law has always been a default mechanism in all of civilization, and hence, ignoring the need to update it would result in apocalyptic effects.

With society 5.0 still having taken form only in the minds of strategists, it is now the ideal period to begin speculating on relevant amendments in law and the legal system that shall be essential to successfully implement it at a potentially global scale.

The doctrine of Rule of Law solidifies this claim, for it states that no one is above the law, irrespective of who they are. It is the first step towards achieving harmony between the legal system and the society, which would directly influence intra-societal well-being.

Society 5.0

It is an undebatable fact written in stone that the human civilization has been evolving and will continue to do so for perpetuity, owing to there seemingly being no concrete end sought or expected. As a result, society has been consistently pushing ahead, constantly breaking boundaries, and inventing what was once unthinkable. We went from being hunters and gatherers in a hunting society to cultivators in an agrarian society as some of the first steps of collective social evolution. Then, the boom of the industrial society settled to give way to the rapidly established information society, at the cusp of which we will find ourselves soon.

An idea has bloomed in Japan, with regards to the next phase of societal evolution. The vision is for us to move forward from employing cyberspace and its elements to work upon our prompts and directions, to incorporating ourselves into cyberspace to realise and apply our potential in a shared manner.

That is the essence of the state of things that Society 5.0 was introduced with the intention of achieving. The ‘5th Science and Technology Basic Plan’ of the Japanese Cabinet adopted in 2016 signifies the intention to steadily move towards the birthing of Society 5.0 at a national level. To further substantiate its cruciality, Society 5.0 was also incorporated as a core constituent of ‘The Investment for the Future Strategy 2017’ of Japan. Initiated in the official capacity roughly 8 years ago, the advent of Society 5.0 is still quite a young initiative and continues to find itself being the centre of various academic and professional discussions globally.

Society 5.0 is described to be ‘human-centred’ and also simultaneously fosters engagement with cyberspace to generate and utilise data to resolve pressing issues and improve the quality of life. The welfare-oriented output of creating such a society can be inferred to be the moulding of a society where every individual can be ‘dynamically engaged’ in its workings and functions, regardless of any setbacks that might be holding them back in the contemporary era. Therefore, true representation and inclusivity may be expected in an ideally functioning Society 5.0, making it a highly desirable model.

Manifestation of Society 5.0 Globally

Japan, the observable birthplace of the concept of Society 5.0, is said to be "an advanced country with advanced issues". With an ageing population and increasing social security expenses posing prime threats to the steady development of the nation in the near future, Japan has emerged to be one of the first of few countries attempting to battle the same crisis. However, it is predicted that other nations will eventually come around to face identical issues subsequently. Society 5.0 is cited as a ray of hope, which, if successful, can branch out from Japan and into the global society, ready to be enforced as and when the need arises.

Society 5.0 is also claimed to be an excellent medium to realise the SDG goals through advanced technology and problem resolution made possible in cyberspace. With the Sustainable Development Goals being one of the most internationally agreed upon set of objectives, regarded in good light by all, being able to chance upon a day where they may be entirely realised seems like a dream.

Japan is currently deep in the process of finalising an 'agile governance' framework, which is set to make governance easy and relatively manageable in the conditions established by Society 5.0. The Agile Governance Update of the Ministry of Economy, Trade and Industry of Japan elaborates upon three facets in relation to it, which are:

Governance for innovation, where, as the name suggests, innovation is encouraged and supported so that the fruits of its benefits may be reaped by all. This is important, as innovation and change have always remained constant. Therefore, in an ideal society 5.0, quality innovation is bound to happen so frequently that it becomes the constant in itself, playing into the famed saying that "change is the only constant."

Governance of innovation, where the holistic idea of revolution and its effects are predicted, analysed and diagnosed in preparation to regulate the same. The government has duly realised that the platform for innovation is set to 'improve' to a state where the ultimate decision-making, to a large extent, would no longer be made by direct human intellect, but by its digital creations. Now that such transformation is an inevitable and integral part of the upcoming societal phase, it is considered ideal to enact statutes and rules to regulate the same.

Governance by innovation, where the procedure of governance is carried out by the outputs of experiments and innovations. While this idea feels far-fetched to the contemporary eye, it must be realised that such an image being projected into reality is not too far away from our time. Technology such as AI, Internet of Things and more are already being implemented in administrative, judicial, executory and legislative processes globally.

Society 5.0 would ideally function at its pinnacle once a state strikes a balance between these three modes. Taking inspiration from the agile governance framework initiated by Japan, any nation can launch the same within its jurisdiction, which would inevitably result in their society evolving to touch upon a new phase, which is what is termed Society 5.0.

Fields of Law Primarily Concerned with the Transformations of Society 5.0

When one is presented with the keyword of Society 5.0, one would think of technology, cyberspace, data, digital learning, science, transformation, metaverse, and such. But the term 'law' would fail to be commonly associated with it by a layman. Ironically though, any society, regardless of all the scientific, technological and advanced elements it harbours, would crumble and fall if not supplemented with a strong and suitable legal framework running through all its crevices like a golden thread. So, it is important to identify the legal boundaries within which we would function, while the world steps into the idea of becoming one with cyberspace.

In Society 5.0, where cyberspace and the physical space are undeniably intertwined, there would be a potentially high risk of breach of information and security of assets which would be commonly shared in such merged space. This is inevitably expected, for even in the current society, where cyberspace and physical space have not become one, a data breach is a running threat to individuals and organisations just the same. Therefore, such risk would be exponentially higher in the future society being discussed.

Information Technology Laws:

There has also been an influx of platforms such as social networking sites and search engines, that have never had direct brick-and-mortar counterparts. This is a sign of the rise of information technology, the utilisation of which has become a common household routine.

Society 5.0 intends to put humans at its centre, where their needs shall be catered to intensively, without discrimination or expending much effort. Undoubtedly, to achieve this peak, the shifting of commercial mediums from physical space to cyberspace will play out at a quicker rate, as intended. Large chunks of information will be consumed to make such a significant transformation successful, and once employed, such cyberspace will also harbour an unimaginably Goliathan mass of information of every kind imaginable, and beyond.

The disastrous end of an unregulated utilisation of the fruits of information technology is easily imaginable. And when impending doom is indubitably predictable, enacting laws to impose bars and restrictions on any element that could bring about such disaster has always been the route to take.

The key laws to focus upon for this evolved society would be the Cyber laws, Privacy laws and lastly Information Technology laws, for the personal lives of all the residents of such a futuristic society would be closely intertwined with cyberspace.

Privacy Laws:

We humans have a natural tendency to seek information, regardless of how substantial it is. Earl Ferrers, a politician, rightly stated “The collection of personal data is as old as society itself. It may not be the oldest profession, but it is one of the oldest habits.”

Information is one of the most powerful tools. Information, however, is also commonly known as the most powerful weapon. Employment of one’s mastery and knowledge to unethically acquire privately stored confidential data too is an ugly child of the above-discussed human habit. Increasing computerization would only feed into the skyrocketing possibilities of successfully accessing such digital storage, especially in a ‘global village.’

This recognition calls for revamped and customised privacy laws, imposing stern restrictions on unauthorised infringement of digital privacy and subsequent access and appropriation of materials obtained that way.

However, every coin has two sides, and in this case, the need to permit ethical violations of digital privacy for purposes of safety and security can be observed on the flipside. The government and other authorised institutions shall need to access private data for a multitude of political, economic and social reasons. Especially in a highly digitised society dependent on the functioning of cyberspace, laws must make way for adequate gaps to accommodate such legal intrusions upon the public’s use of various platforms and technologies. These may include rules that regulate the handling of such procedures by means of tapping into and tracking usage of telecommunication, storing the data collected through such interception and imposing a limit on the extent of encryption technologies.

Ultimately, privacy, which is largely recognized as a fundamental human right, must be provided with the rightful means to be legally protected, regardless of the nature of the society at hand.

Cyber Laws:

Legal practitioner and author August Bequai wrote in the preface of a Council of Europe Recommendation on Computer Related Crime that "In the information society, power and wealth are increasingly becoming synonymous with control over our data banks" and that "The computer revolution has provided tools with which to steal with impunity, control and manipulate the thoughts and movements of millions, and hold an entire society hostage."

Jurist and Professor Dr. Ulrich Sieber, in his report for the 1998 COMCRIME study, compared international computer networks to "the nerves of the economy, the public sector and society." With the current society being commonly acknowledged as the information society, even a minute attack on our computers could trigger a butterfly effect, with dominoes toppling along next to a collapsing society.

Cybercrimes enable the projection of physical methods onto cyberspace as well, thus effectively mirroring the core of Society 5.0, except, it paves the way for crimes to be committed digitally. As commonly observed, petty crimes including theft, white collar crimes including fraud, infringement of intellectual property, sex crimes and more are being committed with relatively more ease owing to near unrestricted access to the nooks and crannies of the internet. In Society 5.0, the list would only keep growing exponentially once wider regions of cyberspace are unlocked for access to fulfil the goal of a 'human-centred society'.

Hence, stringent and efficient legal systems would be the need of the hour at the onset of Society 5.0. Multiple joint initiatives such as the Cybercrime Convention must be regularly held to finetune and amend related laws at an international level. The diverse types of crimes that can be committed through cyberspace must be painstakingly identified and resolved expertly using the law.

Preference of International Law over Domestic Law

The internet and the digital world are not restricted to one nation's borders today, and hence, that would not be the case in the near future either, for with more advancements, the means to access it would only expand. While the physical world has been divided geographically, culturally, linguistically or by any other means, the same is rarely reflected in cyberspace, making digital users greatly vulnerable to cyber threats due to this wide range of unrestricted accessibility. There is absolutely no guarantee that the eye of a cyber-attack will certainly be traced to a location within the physical boundaries or even the jurisdiction of the region where the attack was directed, as cyberspace is accessible globally by various means, be it ethical or not. Costa Rica's ransomware attack followed by the state's declaration of emergency is an unfortunate example substantiating such predicted fear. While domestic laws do serve more specialised and exclusive purposes, upon the onset of a mega wave of cyberspace incorporation threatening to engulf various lands, it is high time for countries to jointly lay the foundations for a treaty or a convention, and through make applicable such international laws that direct and bring upon binding restrictions on the activities that occur in cyberspace. This remains true despite Japan currently being the only nation marching towards opening up a portal to Society 5.0, for in the digital era, one nation's technological advancements mean direct or indirect impact on every other state.

Laws Today and their Lacunae

The initiative was taken in 2021 at the United Nations AD HOC Committee, through the signing of the UN Cybercrime treaty to curb cybercrime. After the agreed upon three years of negotiation, which included multiple sessions, the treaty is now only a few steps away from

execution. It has been adopted unanimously by the Ad Hoc Committee in the United Nations and has now been moved to the United Nations General Assembly to receive the final and deciding approval.

Privacy Laws:

The primary objective of privacy laws in general was to ensure a restraint on unauthorised access to information and data related to an individual or legal person. The modern principle has evolved to secure a restriction on the unwarranted use of personal and confidential information as well. Said principle has come to assume the name of 'fair information practices.'

A commonly observed collective trait of privacy laws across the globe is the mandate made upon organisations to furnish a notice at every instance where private information is recorded, used or shared. The concerned person shall be presented with the choice to allow the utilisation of such information in the means disclosed by the organisation. They may even customise such a choice by picking and choosing where their data may be used and where it may not be uncovered. This disables misuse and unauthorised use of data collected through the trust of those sharing it. This way, accountability is lawfully placed on those who collect sensitive private data to guarantee the maintenance of its confidentiality and security. Owing to the nature of this obligation arising from a medium akin to that of a contract as the layman knows, upon any slip-up where the security of such protected data is compromised, the organisation may be held liable for breach of privacy. This is the current stance of privacy laws globally.

However, even with the recent trends in technology not being any overbearing as it may be in Society 5.0, the privacy law system does face setbacks. The striking absence of any true restrictive boundaries online, in comparison with the existence of sturdy physical partitions plays a significant role in rendering the easy preservation of digital privacy a daunting task. With the sufficient number of resources and ample knowledge coupled with nimble skillsets, one may break down online protective shields with little effort. This would project a gaping hole in the ensuring of societal wellbeing and tranquillity in Society 5.0, where the infringement of digital privacy would only be as simple as its protection, for with the eradication of all setbacks, one is free to hone his skills and abilities only to use it as he wishes.

It must also be noted that despite there being an existence of a jointly agreed upon principle providing life to privacy laws globally, international consistency ceases there. For instance, in the United States, digital privacy is coloured with the goal of preventing the government's intrusion into one's life. Meanwhile in Germany, privacy is synonymous with human dignity and is hence protected accordingly. On the other hand, the European Union looks at privacy through the lenses of fundamental rights of the people, owing to steps being taken to preserve the rights with suitable importance assigned to it.

However, such inconsistencies will only prove to be looming threats once Society 5.0 is established at a universal level, for the digital area and cyberspace are not confined within the likes of borders or clear jurisdictions. A unified set of rules to regulate issues related to digital privacy would be crucial to facilitate the intended functioning of such a society.

Cyber Laws:

It is ideal to begin by establishing the importance of jurisdiction in the legal system. When an offence, breach, crime or any violation of the law is committed, the perpetrators in question may be tried for it only at the courts and tribunals that have the rights and the powers to hear such cases. With municipal law, such jurisdiction is distinctly established through national statues. It is not baffling to ascertain that a nation has the power to try offences committed within its borders, for the violative act took place in its lands. However, the same rationale cannot be easily applied to cyberspace that often lacks intelligible perimeters. Without bounds and respective jurisdictions being agreed upon with glaring clarity, the very process of

trying a case so as to bring justice would prove to be a formidable task, with multiple parties laying claim. This would plunge the world into chaos spanning international spectrums, defeating the very purpose of a human centred, restriction-erasing Society 5.0.

Trickier than with framing regulations for digital privacy, doing the same to apply to the indefinite cyberspace would not succeed unless drafted with utmost care to make it fluid and yet firm enough to impose stringent and practical penalties.

Information Technology Laws:

The laws related to IT will be governing the more technical aspect such as ensuring the security of Information on the internet, with relation to the technology in use. With emerging technologies and languages, there are always creative ways to store information, but the concern irrespective is if the mode of storage is susceptible to information breach attack or misuse. Raising techs such as blockchain also have sparked the debate of the right to be forgotten for information stored as that is less likely an option.

The laws under this field will mostly undergo amendments to keep up with the basic requirements, as the major governance is covered under cybersecurity laws and privacy laws.

Diagnosable changes in these laws in the face of society 5.0

Privacy Laws:

The data in question here may be perceived akin to property over which an individual may exert ownership and title over, especially owing to the fact that economic value is attached to such data. Increasing value of data is directly proportional to how privately and securely it is guarded. Certain chunks of information are even regarded at a higher value than money by some companies and innovators, trade secrets being an apt example. Such a point of view helps materialise data to make it subject to property laws as well. With both legal frameworks working in harmony to secure digitally stored data with the ultimate aim of protecting the privacy of its owner, certain gaps and lacunas may be filled.

Moreover, a joint international conference to explore the national privacy laws of multiple states to examine the feasibility of an array of provisions in enhancing Society 5.0 would be an ideal means to compile a common foundational set of digital privacy-regulating rules at an international setting.

Cyber Laws:

As globalisation continues to proliferate showing no signs of ceasing anytime soon, blurring borders and increasing access to shared digital spaces are inevitably signified. It is safe to assume that Society 5.0 would marvellously cater to this rapid mushrooming by eradicating barriers holding zealous individuals back from truly assimilating as a global citizen. Hence, geographical limitations would be reduced to a thin line in cyberspace, with its existence serving only administrative and political purposes.

However sensitive data holding the bedrock of entire nations intact would also be stored and sealed in such cyberspace. Thinning lines of demarcation pose a domineering peril of a targeted cyber-attack being successful in breaking through the seals and of the confidential data ultimately ending up in wrong hands.

Setting up distinct demarcations between private and public information would be the ideal manner to go about such an issue. The cyber laws will function as the second constitution in this new society, establishing fundamental rights and duties of its own, while there is a primary focus on conduct, privacy, and speech and expression of parties. Also keeping in mind that the systems in administration will rely on these said laws as guidelines, the future laws will have to be more definitive with minimum scope of interpretation, while also aiming to be preventive and not protective.

LITERATURE REVIEW

The book 'Society 5.0: A People-centric Super-smart Society' is intricate and comprehensive in detailing every aspect with regards to Society 5.0 and hardly falls short.

In the World Development Report 2017 by the world bank, it had quite clearly been explained how law has developed through history while playing a vital role in the society. It starts from the code of Hammurabi to the current rule of law, while also elaborating on how law and society gelled and grew together.

Why rule of law is the bedrock of sustainable development is a short blog post which specially focuses on rule of law, and its relevance backing up the tool that was developed by the International Bridges to Justics (IBJ).

In 'Society 5.0: Aiming for a New Human-Centred Society' by Mayumi Fukuyama, the emergence, objectives, needs and effects of Society 5.0 are discussed, but it fails to throw light upon the setbacks and barriers.

The Cabinet Office website of Japan too houses a description of the nation's views and plans for the implementation of Society 5.0. However it is strikingly brief and crisp.

Governance for Society 5.0 is a post which includes a basic introduction of society 5.0, and then proceeds to elaborating the planned governance plan that the Japan's Ministry of Economy, Trade and Industry has formulated. It has quite accurately summarized the report and its goals for governance of society 5.0.

Of the book 'Information Technology Law', chapter abstracts were accessible online, which enshrined brief but sufficient data regarding various facets of information technology law, including its elements, regulation, licensing, protection and more. However, it was highly specified with limited content to present.

A post titled Costa Rica state of emergency declared after ransomware attacks brings light to the ransomware attack that the costa rica government was subject to in April 2022. It covers both incidents, speculations on the motive and the damages incurred by the government.

'What is the UN cybercrime treaty and why does it matter?' is a post that cover the holes left behind by the lack of an international cybercrime laws, and the steps taken by the United Nations to attempt to bring an international cybercrime treaty.

Another post, 'UN cybercrime treaty passes in unanimous vote' was analysed where it updates the readers about the recent event where the UN Ad Hoc Committee had unanimously passed an international cybercrime treaty, and handing it over to United Nationas General Assembly for the final decision. The post is accurate and concise.

A reference has also been made to the official press release of United Nations office on Drugs and Crime, which confirms the unanimous passing of a new cybercrime convention in the Ad Hoc Committee. This convention could potentially improve international cooperation.

Emerging trends in international privacy law is a detailed research paper which covers how privacy had come to be important, to how it will potentially be viewed in the future. It acts as a guideline for framing futuristic laws.

The origins and future of international data privacy law, another research paper, had a comparative analysis of privacy in the settings of different settings, resulting to the respective laws that the countries have in current times. Privacy can be viewed in different angles through this paper.

A paper titled 'International cyberspace: from borderless to balkanized' emphasised the current loophole of not having common international laws to govern cyberspace owing to its international level risks.

'The distributed liability of distributed ledgers: legal risks of blockchain' informs about the technology of blockchain in the field of financing, but in legal context.

The future of information technology law is a paper predicting the most basic, yet close to perfect futuristic utilization of information technology. Possible changes in the future laws are also considered.

The obligation to prevent transboundary cyber harm: expand the regulatory regime or continue deflecting responsibility is a paper that sets down the rights and duties in the cyberspace, while also attempting to suggest a few methods to avoid the impending risks the state will face.

In the article 'Who Will Be the Members of Society 5.0? Towards an Anthropology of Technologically Posthumanized Future Societies' by Matthew E. Gladden extensively elaborates upon the nature, application and participants of Society 5.0. It is complete and detailed, with due recommendations made.

DATA AND METHODOLOGY

Upon a perusal of multiple journals, books and online resources, this paper was drafted as a result of such doctrinal research, where the authors first understood the implications of Society 5.0 and subsequently overlayed applicable laws with the intention to identify plausibility and practicality of such ambitious future society.

RESULTS AND DISCUSSION

As it has been mentioned repeatedly throughout the course of this paper, acquiring an international consensus would be paramount to be able to safely and effectively regulate the world upon the onset of a global Society 5.0. However, it is an arduous task to succeed in, for it has always translated to one of the largest barriers in international law from time immemorial.

All nations of the world do not even conform to one uniform legal system. Diversity exists in the systems of common law, civil law, customary law, religious laws, mixed systems and more. Owing to this heterogeneity, the ideologies, theories, opinions, policies, thoughts and structures constituting the legal system of each state varies greatly.

Finalising accountability in the face of errors committed by technological mediums in spaces of authority and decision making is critically essential in a society with non-human members dictating human lives, however it is easier said than done. The emergence of AI alone has thrown various fields of law off balance with the question of 'who shall be responsible?', so, frantic scurrying to seek out an accountable pillar to assume liability in Society 5.0 would be gruelling.

The diagnosis is that it is, in fact, clear that major legal amendments and restructuring would be mandatory to enable Society 5.0. The catch lies in the realisation that this realisation does not make it any easier for the necessary changes to be actually applied, owing to the extensive barriers, lacunas, and impracticalities discussed.

CONCLUSION

To state it simply from a purely legal standpoint, Society 5.0 is not plausible.

Society 5.0 can be described as a means of 'creative destruction', in the name of innovation. With a cyber-physical world functioning parallel to the physical human realm as

we know it today, there would then be a clear distinction from the previous stages of societal evolution.

To add on to the whiplash-inducing change, an array of non-human actors is also expected to be incorporated into Society 5.0, not as tools, but as functional members. Robots, Artificial Intelligence and Life, Self-Directing and Organizing Computer Networks, and more would constitute the swarm of newfound societal members. Alarmingly, by current standards, these non-human components will be significantly more autonomous and uncannily sentient.

There are also mentions of the lives, bodies and minds of individuals being transformed through the assimilation of technology. The Internet of Things, field of neuroscience, advanced medicine, will impose great effects on everyday lives of the citizens of Society 5.0.

With the assimilation of near-sentient non-human elements into the most intimate crevices of one's living, the true role and position of humans in such a society falls under question. The promises of ensuring a human-centred Society 5.0 simultaneously with the amalgamation of autonomous technologies seem to run parallelly, with no scope to intercept or complement one another.

With such sharp switches being difficult even for the human mind and morality to comprehend without mild horror, there is still a long way to go for law to be able to efficiently step into regulating the same, for anything that is not accepted by the society will eventually come to cease, requiring no legal intervention.

REFERENCES

Agile Governance Update: How Governments, businesses and civil society can create a better world by reimagining governance (Vol. 3; GOVERNANCE INNOVATION). (2022). Ministry of Economy, Trade and Industry. https://www.meti.go.jp/press/2022/08/20220808001/20220808001-b.pdf

Costa rica state of emergency declared after ransomware attacks. (n.d.). Security Intelligence. Retrieved October 15, 2024, from https://securityintelligence.com/news/costa-rica-state-emergency-ransomware/

Gladden, M. E. (2019). Who will be the members of society 5. 0? Towards an anthropology of technologically posthumanized future societies. Social Sciences, 8(5), 148. https://doi.org/10.3390/socsci8050148

Governance for Society 5.0. (n.d.). Retrieved October 15, 2024, from https://www.chandlerinstitute.org/governancematters/governance-for-society-5-0

Kohl, U., & Charlesworth, A. (Eds.). (2011). Information technology law (4th ed.). Routledge. https://doi.org/10.4324/9780203148297

Ltd, H. (n.d.). Society 5. 0: Aiming for a new human-centered society: Japan's science and technology policies for addressing global social challenges: Hitachi review. Retrieved October 15, 2024, from https://www.hitachihyoron.com/rev/archive/2017/r2017_06/trends/index.html

Medina-Borja, A. (2016). Smart Human-Centered Service Systems of the Future (CRDS-FY2016-WR-13; Future Services & Societal Systems in Society 5.0). Center for Research and Development Strategy, Japan Science and Technology Agency. https://www.jst.go.jp/crds/pdf/en/CRDS-FY2016-WR-13.pdf

Ozanian, A. (2015, September 25). Why rule of law is the bedrock of sustainable development [Online post]. World Economic Forum. https://www.weforum.org/agenda/2015/09/why-rule-of-law-is-the-bedrock-of-sustainable-development/

Society 5.0. (n.d.). Cabinet Office Home Page. Retrieved October 15, 2024, from https://www8.cao.go.jp/cstp/english/society5_0/index.html

UN cybercrime treaty passes in unanimous vote. (n.d.). Retrieved October 15, 2024, from https://therecord.media/un-cybercrime-treaty-passes-unanimous

United Nations: Member States finalize a new cybercrime convention. (n.d.). United Nations: Office on Drugs and Crime. Retrieved October 15, 2024, from https://www.unodc.org/unodc/en/frontpage/2024/August/united-nations_-member-states-finalize-a-new-cybercrime-convention.html

Wilkinson, I. (2023, August 4). What is the UN cybercrime treaty and why does it matter? [Text/HTML]. CHATHAM HOUSE. https://www.chathamhouse.org/2023/08/what-un-cybercrime-treaty-and-why-does-it-matter

World development report 2017: Governance and the law. (n.d.). [Text/HTML]. World Bank. Retrieved October 15, 2024, from https://www.worldbank.org/en/publication/wdr2017

IMPLEMENTING BUBBLES OF INTEGRITY: SOAP'S ROLE IN SANITIZING ONLINE EXAMS

Rowena Viñan[A], Joseph Tuazon[B], Jallen Rose Manalo[C], Eriberto Roxas Jr.[D], and Reinald Adrian Pugoy[E]

ABSTRACT

The rapid rise in global demand for online education, driven by its flexibility and broad access to learning opportunities, has also increased unethical student behaviors, particularly during online examinations. This growing concern highlights the need for practical tools to uphold academic integrity in the digital learning environment of the University of the Philippines Open University (UPOU).

In this regard, UPOU, through its ICT Development Office, has developed the Specialized Online Assessment Platform (SOAP) to provide a cost-effective and easy-to-implement automated proctoring system that meets certain academic and ethical standards. It uses various technologies such as OpenCV, which recognizes people and objects from images and videos, MongoDB, which manages the data, ReactJS, which builds interactive user interfaces, and Flask, a web framework for Python that integrates with AI.

The SOAP project's main contribution lies in providing advanced capabilities for automated proctoring using the above-mentioned technologies. These were researched, tested, and integrated into a functional prototype with critical features such as student informed consent, student face identification, bystander detection, unauthorized object detection, cheating probability calculation, and violation reports. Although these AI-generated analyses proved effective in detecting potential cheating behaviors, instructors are granted final discretion to manually review the reports to verify genuine violations and reduce false alarms.

Keywords: *Online Examination, Cheating, Academic Integrity, Online Assessment Platform, Online Education, Unethical Student Behavior, Digital Learning, UP Open University, Proctoring Solution, SOAP, Specialized Online Assessment Platform*

[A] *Faculty of Information and Communication Studies, University of the Philippines Open University, Laguna, Philippines. Email: rsvinan@up.edu.ph*

[B] *Institute of Computer Science, University of the Philippines Los Baños, Laguna, Philippines. Email: jdtuazon1@up.edu.ph*

[C] *Institute of Computer Science, University of the Philippines Los Baños, Laguna, Philippines. Email: jtmanalo1@up.edu.ph*

[D] *ICT Development Office, University of the Philippines Open University, Laguna, Philippines. Email: eeroxas@up.edu.ph*

[E] *Faculty of Information and Communication Studies, and ICT Development Office, University of the Philippines Open University, Laguna, Philippines. Email: rdpugoy@up.edu.ph*

INTRODUCTION

Academic dishonesty, mainly cheating, has been a recognized issue as early as the 1900s (Osei, 2019; Fass-Holmes, 2017), with many cases emerging during non-proctored online exams (Osei, 2019; Shute & Rahimi, 2017; Sadik, 2016). The International Center for Academic Integrity (ICAI, 2020) reports alarming statistics, with a survey of over 70,000 high school students across 24 U.S. high schools revealing that 64% admitted to cheating on a test, 58% confessed to plagiarism, and 95% participated in some form of cheating. While students know cheating is wrong, they often do not regard it as serious misconduct (Osei, 2019; Newton, 2016).

As academic dishonesty rises alongside the growth of online education (Osei, 2019; Fass-Holmes, 2017), there is a pressing need for security measures in online assessment proctoring (Osei, 2019; Rios & Liu, 2017). Fidas (2023) notes that many Higher Education Institutions (HEIs) face challenges in effectively detecting academic dishonesty during online exams. Learning management systems and video conferencing tools typically authenticate student identity only once before the exam. Students enter a text-based password into the learning platform and present identification to an instructor or invigilator via webcam. However, this approach allows students to circumvent after the initial authentication (Fidas, 2023; Frank, 2012). Issues such as communication (voice or text chat), collaboration (remote access and screen sharing), and access to restricted materials (online resources, search engines, and hard copies) undermine the effectiveness of these systems. Additionally, infrastructural barriers, such as internet outages, power disruptions, device malfunctions, and server issues, further threaten exam integrity (Bhardwaj, 2020; Muzaffar et al., 2021).

The University of the Philippines Open University (UPOU), a leader in Open and Distance e-Learning (ODeL) in the Philippines, also recognizes the risk that academic dishonesty poses to the credibility of online education. UPOU currently employs both a learning management system and video conferencing tools. A dry run (mock test) is conducted at least one week before the exam to lessen technical challenges and to help students familiarize students with the setup and format. During the actual exam, students log into a video conferencing tool using two devices: a laptop or desktop computer with a webcam and a secondary camera (smartphone). These devices follow prescribed guidelines, with the student sharing their screen and showing empty sheets of paper. Throughout the exam, the proctor monitors student activities manually, and after the exam, the student may be asked to discard the rough sheets (scratch papers). While designed to uphold academic integrity, the overall process is resource-intensive and places a heavy burden on the proctor.

In this regard, the UPOU has launched the Specialized Online Assessment Platform (SOAP) project, which addresses several key challenges:

- A lack of robust and sophisticated proctoring technologies
- Manual identity verification processes
- A shortage of teachers available to proctor exams leads to higher costs
- The complex setup and installation processes for proctored exams
- The potential negative impact on the student experience

The SOAP project aims to develop a non-human proctored online assessment platform and compare it against similar proctoring methods, such as existing online proctoring programs and open-source alternatives. Its goal is to enhance academic integrity without compromising the student experience.

LITERATURE REVIEW

The Examination Services Unit of the Office of Student Affairs (OSA) mitigates academic dishonesty through remote proctoring and strict adherence to exam prerequisites such as policy compliance, internet bandwidth requirements, and using prescribed devices and examination venues. The proctor logs any unusual incidents for further review. UPOU is exploring ways to augment its proctoring capabilities in light of evolving technologies, ensuring integrity while improving the student experience. This review examines current solutions and technologies in online proctoring.

A. Online Proctoring Programs

Arnò et al. (2021) categorize online proctoring programs into three main types: live proctoring, recorded proctoring, and automated proctoring. Live proctoring, introduced in 2006, involves human proctors who authenticate, monitor, and supervise students in real-time. By 2015, live proctoring had expanded, with thousands of assessments being monitored monthly. Recorded proctoring eliminates real-time supervision, instead recording the exam session for later review. Automated proctoring utilizes AI to monitor students in real-time, automatically flagging anomalies based on behavior.

Arnò et al. (2021) found that while these tools are widely available and helpful, they present limitations, including high costs due to licensing fees and subscription schemes. Despite its sophistication, automated proctoring often introduces challenges related to internet connection issues, lighting, and device quality, leading to inaccuracies in detecting cheating. For instance, AI might flag head and eye movements as suspicious, which, upon human review, could be deemed normal behavior. Similarly, the AI might fail to detect a person reflected in a window behind the student, as in one case.

Osei (2019) emphasizes that live proctoring and remote live proctoring remain the most effective means of ensuring exam integrity, though their costs are significant. Osei discusses Respondus Lockdown Browser and Monitor, a solution widely adopted by over 400 institutions, as a reliable tool. It locks students' browsers during exams, integrates with Moodle, and uses webcams and screen recording to monitor activities. However, despite widespread use, studies on the overall effectiveness of Respondus are limited.

Dewar (2023) highlights the ethical concerns of AI-powered proctoring tools such as Proctorio. At California Virtual Campus Online Education Initiative (CVC-OEI), Proctorio was discontinued in 2021 due to concerns about AI bias, particularly against students with darker skin tones, disabilities, or those in non-isolated environments. This bias raises essential questions about fairness, inclusivity, and the potential for bias in AI algorithms.

Tweissi et al. (2022) highlighted notable criticisms of machine learning algorithms in online proctoring, particularly when citing Coghlan et al. (2021). These algorithms flagged inaccuracies and biased judgments, especially concerning individuals with darker skin tones. This concern over discrimination prompted ProctorU to discontinue its AI-only proctoring model (ProctorU, 2021a, 2021b). Their decision came after reports that over 10% of the 1.5 million exams monitored over 12 months required active human intervention, emphasizing the limitations of AI systems in ensuring fairness and accuracy. This statistic underscores the necessity for a hybrid proctoring model, combining AI and human oversight, to maintain the credibility of online exams (Slusky, 2020; Miguel et al., 2015).

B. Open-Source Proctoring Tools

Open-source proctoring tools offer customizable, free solutions for institutions but often lack the premium features and support that commercial products offer.

Proctor SU

One notable open-source tool is Proctor SU, which was developed for online Kazakhstan exams. Nurpeisova et al. (2023) describe Proctor SU's use of facial detection, audio capture, and gaze evaluation to monitor students during exams. The system uses HTML, CSS, JavaScript for the front end, Python with the Django framework, and PostgreSQL for the backend. It employs the YOLOv3 model for real-time face recognition, tracking students at 45 frames per second.

Proctor SU's key strength lies in its ability to track large groups of students simultaneously. However, concerns related to privacy, AI trust, and the lack of adequate training for users have hindered broader adoption. Additionally, addressing issues due to poor internet connectivity and limited technical support could improve its scalability and reliability.

TRUSTID

TRUSTID, another open-source solution studied by Fidas (2023), focuses on continuous student identity verification through facial and voice recognition. This tool prevents impersonation by continuously comparing live data against stored reference images. The study demonstrated the effectiveness of TRUSTID in detecting impersonation attempts by a limited number of participants, while the inability to detect fake video streams was noted as a limitation.

Safe Exam Browser (SEB) and Registry Changes View

Mohammed et al. (2022) studied the integration of Safe Exam Browser (SEB) and Registry Changes View, particularly in Moodle-based platforms. SEB restricts access to unauthorized applications and websites, creating a secure environment for students to take exams on their devices. However, SEB's functionality is sometimes considered inferior to that of the Respondus Lockdown Browser, particularly regarding reliability. Mohammed et al. suggest that additional measures, such as surveillance cameras and system controls, are needed to supplement SEB's limitations, especially for detecting unauthorized collaboration or device use. Table 1 below differentiates SEB from the Respondus Lockdown Browser.

Table 1 – A comparison between SEB and Respondus Lockdown Browser

Feature	SEB	Respondus LD Browser
Full-screen mode	Yes	Yes
Disallowing opening a new tab or another website	Yes	Yes
Keyboard shortcuts and keystroke combinations	Can be disabled	Can be disabled
Mouse menus (e.g. printing, copy/paste, task switching).	Can be disabled	Can be disabled
Open source	Yes	No
Native application.	Yes	Yes
Automated proctoring.	No	Yes, using Respondus Monitor app.
Data encryption	Yes	Yes
Integration with Moodle LMS	Yes	No, needs Moodle Extension
Screen recording by student	Can be disabled	Can be disabled
Support for live-remote proctoring	No	Yes, via Zoom and Jitsi Meet
Remote desktop app.	Denied with version 3.1.1 and higher	Denied
VM detection	Yes	Yes
Purchase fee	Free	Depending on the volume

Source: Prepared by Mohammed et al (2022)

AI, Machine Learning, Deep Learning, and Computer Vision

Tweissi et al. (2022) describe Artificial Intelligence (AI) as a branch of computer science that simulates human cognitive functions, particularly in processing large volumes of data. AI has significantly shown advancement in numerous fields, including education, medicine, business, environmental studies, and communication.

Mitchell (1997) defines Machine Learning (ML) as a subfield of AI focused on developing algorithms that enable computers to recognize patterns in data. Over time, these systems learn autonomously, improving their decision-making and prediction ability. ML is the foundation for various technologies, such as recommendation systems, fraud detection, natural language processing, and robotics.

According to Goodfellow et al. (2016), Deep Learning is a specialized area of machine learning that allows computers to learn and understand the world through a network of interconnected layers, which can process complex patterns across domains such as image and speech recognition, natural language processing, and autonomous systems.

Szeliski (2010) describes Computer Vision as a branch of AI that enables computers to analyze and interpret visual data, including images and videos, and classify them into objects, scenes, and actions. Applications include facial recognition, autonomous driving, and medical image analysis.

Ozdamli et al. (2022) propose an advanced proctoring system incorporating Computer Vision, Deep Learning, and AI technologies. Their system uses OpenCV to capture images and enhance object recognition, Mini Xception Convolutional Neural Networks (CNNs) to predict facial emotions, and YOLOv3 to detect objects in real-time. The system flags suspicious behaviors such as unrecognized faces, prolonged gaze shifts, or the presence of multiple faces during the exam. While these technologies significantly improve monitoring accuracy, challenges persist, including poor internet connectivity and the system's inability to detect real-time cheating reliably, especially for students with unique needs or atypical behaviors.

Proposed Direction

We reviewed the strengths and limitations of online proctoring solutions. While these programs offer flexibility and can streamline exam processes, they often come at a significant cost and face challenges related to internet reliability, bias, and privacy concerns. Notably, there needs to be more research evidence supporting the effectiveness of automated online proctoring in accurately detecting cheating without human oversight (Osei, 2019; Fidas, 2023; Tweissi et al., 2022).

The potential for AI to misidentify suspicious behavior or generate false positives raises severe concerns about the fairness of online exam monitoring. Facial recognition algorithms received criticism for their lower accuracy in identifying individuals with darker skin tones (Coghlan et al., 2021). Such biases not only compromise the integrity of the proctoring process but also threaten to disproportionately penalize specific demographic groups, further exacerbating existing educational inequalities (Slusky, 2020). In addition, future developments should consider fairness regardless of race, ability, or socioeconomic status (Dewar, 2023) while aligning with privacy regulations such as the GDPR and FERPA.

Given these limitations, we advocate for a hybrid model that combines AI algorithms with human proctors (ProctorU, 2021a). Human oversight can mitigate AI's shortcomings by providing contextual judgment, especially in complex situations where algorithms may struggle to distinguish between legitimate and suspicious behavior. This hybrid approach is viewed as a more equitable solution, offering scalability and fairness in the online exam

process (Miguel et al., 2015).

However, the literature remains gaping regarding the long-term effectiveness of hybrid models and the potential for AI to improve over time. Further research is necessary to explore how advances in AI technology could mitigate bias and whether hybrid models can be scaled while maintaining the integrity of assessments.

For UPOU, a hybrid approach that combines AI-driven features, such as computer vision, with human oversight could be the most effective way forward. Focusing on the simplification of proctoring procedures while upholding academic integrity without relying solely on automated systems will safeguard UPOU's reputation and enhance the exam experience for students. Furthermore, ongoing evaluation and adaptation of proctoring technologies are essential to meet the institution's evolving needs.

METHODOLOGY

This study employs an applied research approach with a literature-based design, combining problem-solving strategies with insights from existing literature to design a practical and customized online proctoring solution. The research focuses on detecting student misconduct during online examinations in ODeL (open and distance e-learning) programs, which pose credibility risks for academic institutions. The goal is to develop a solution tailored to UPOU's specific needs, addressing real-world challenges while ensuring exam integrity.

The methodology includes action research through collaboration with other educators and administrators, broadening the scope and contextual understanding of online exam misconduct and detection strategies. By leveraging literature and stakeholder feedback, the study integrates flexible online assessment methodologies into the development process of the proctoring solution.

Phase 1: Problem Identification

An initial needs analysis was conducted through interviews with students and educators, identifying challenges in the current online proctoring system. The participants described a "double setup" proctoring process, allowing students to take exams remotely using platforms such as Google Meet and Zoom, with mobile phones as secondary cameras to monitor surroundings. Browser does not have a lockdown, and proctors manually flag suspicious activities based on remote monitoring.

Common challenges include:

- Impersonation, plagiarism, and unauthorized resource access.
- Proctors need help in monitoring large volumes of students and accurately identifying examinees.
- Trust-based monitoring, where educators infer cheating tendencies based on students' prior behavior in class.

These challenges informed the scope of the proposed automated proctoring solution.

Phase 2: Review of Existing Online Proctoring Solutions

We conducted a comprehensive literature review to analyze how academic institutions address online exam misconduct. Solutions ranged from commercial off-the-shelf online proctoring programs to custom-built AI-powered platforms. Institutions that opted for remote

proctoring highlighted concerns over the reliability of AI versus human invigilators. Most AI-driven proctoring solutions use object and face recognition from video streams, with speech recognition still developing.

The evaluation criteria for these solutions included:

- Cheating detection accuracy.
- Intrusiveness of proctoring technology.
- User experience for both students and instructors.

Phase 3: Objectives and Goals Setting

We propose a new proctoring solution called the Specialized Online Assessment Platform or SOAP that will meet four key objectives:

1. Integrity – Ensuring cheating detection accuracy for a fair assessment.
2. Efficiency – Automating the proctoring process to reduce the need for human oversight.
3. Objective Assessment – Evaluating student behavior impartially based on data.
4. User Experience – Providing a non-intrusive experience that minimizes discomfort and privacy concerns.

We prefer a non-intrusive approach to simplify the proctoring process; thus, we deliberately excluded restrictive controls such as lockdown browsers. Instead, SOAP focuses on recording video feeds to detect potential cheating, with features including:

- Configurable exam URLs
- Detection and analysis of faces and objects from student's webcam feeds.
- The reporting facility enables instructors to review and override flagged activities.

Phase 4: Prototype Design and Development Technologies

The SOAP prototype was developed as a web-based platform, leveraging computer vision to monitor student behavior during exams. Its key features include:

- Student Face Identification: Verifies student identity by comparing live video feeds with pre-stored reference images.
- Bystander Detection: Flags the presence of individuals other than the examinee based on the image analysis.
- Unauthorized Object Detection: Identifies unauthorized materials such as mobile phones or textbooks in the exam environment.

The system architecture integrates the following modern technologies (as illustrated in Figure 1):

- Frontend: ReactJS powers the user interface.
- Backend: Python Flask handles processes such as face recognition and video analysis.
- Database: MongoDB stores student data, including exam-related records and evidence of potential cheating.
- Computer Vision: OpenCV and DLib are used to detect anomalies, such as unauthorized faces or objects.
- Security & Authentication: Google OAuth is customized to manage user credentials and ensure secure access. First-time users register subject to the administrator's approval of the student information and uploaded image.

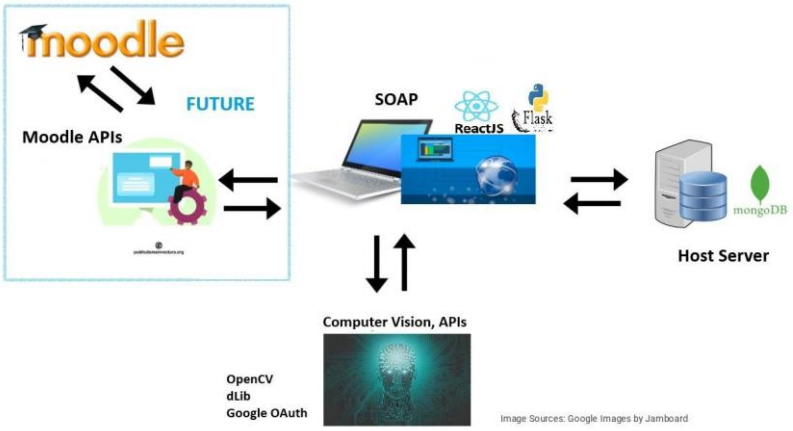


Figure 1 – SOAP System Architecture

Detection Algorithm

The server hosts the cheating detection analysis, which is scheduled after the exam. This approach prevents lags affecting SOAP's responsiveness during the student's ongoing assessment, contributing to a seamless user experience and enhancing overall system performance.

Situation analysis reports provided to educators include cheating probability estimates based on predefined algorithms. These algorithms assess various factors such as the number of persons detected, the presence of cell phones, laptops, books, and TVs, as well as face recognition and detection results. For each screenshot, a score is assigned based on these indicators: face not recognized (2.0 points), no faces detected (1.5 points), multiple persons detected (1.0 points), and detection of a cell phone (0.8 points), laptop (0.8 points), book (0.5 points), or TV (0.5 points). The total score for all screenshots is then normalized using a threshold factor of 3.0. We calculate the normalized score by dividing the total score by the maximum possible score across all screenshots, multiplying by 100, and then by the threshold factor. The algorithm ensures a more sensitive final score, capped at 100% to represent the likelihood of academic dishonesty.

Proposed Workflow

SOAP supports the following workflow for users:

1. User Registration:
   - New users are required to register by providing personal details such as First and Last Name, email address, and student number and then uploading a reference photo for facial identification (Figure 2).

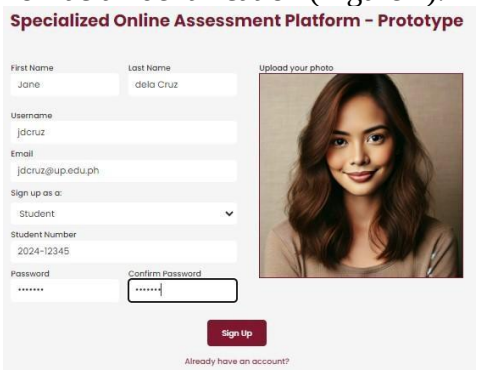


Figure 2 – Student's Registration

- These details and the photo are then submitted for review and approval by an administrator (Figure 3).

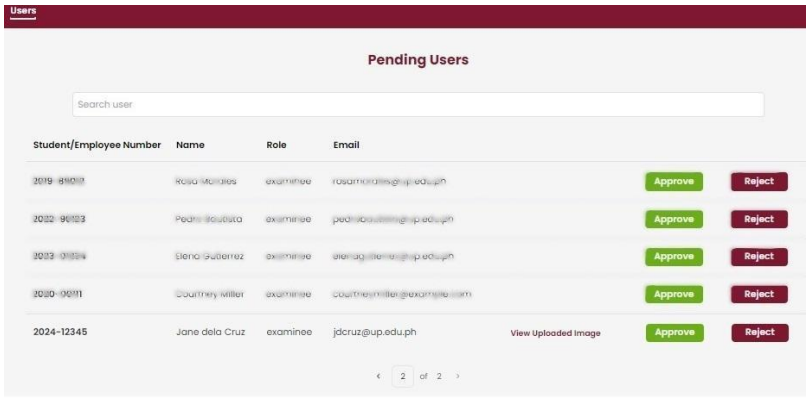


Figure 3 – Administrator's Approval

2. Login & Authentication:
   - Authorized users can log in to SOAP using traditional credentials or Google authentication (Figure 4).

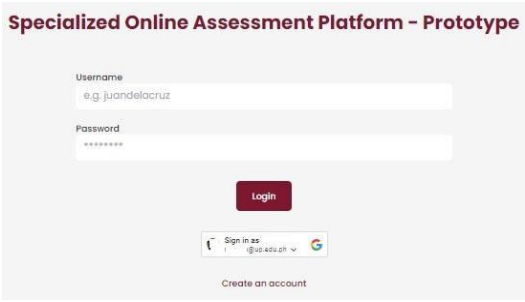


Figure 4 – Login Screen

3. Verification Process:
   - Upon successful verification, users can access their dashboard, where available exams are displayed (Figure 5). If authentication fails, users receive a warning and are unable to proceed to the next step.

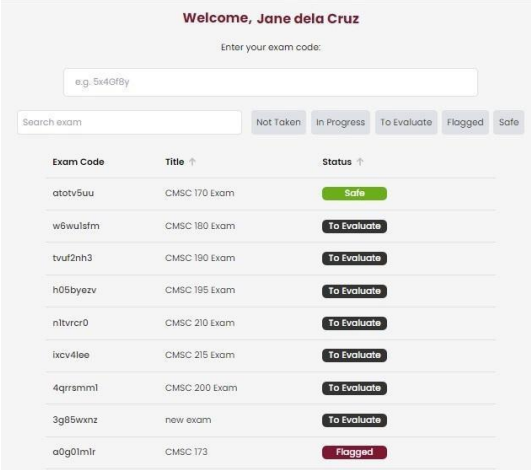


Figure 5 – Student's Dashboard

4. Exam Process:
   - SOAP prompts the students that video recording will be active throughout the exam.
   - Upon informed consent, SOAP redirects them to the exam portal and verifies the student's identity through facial recognition by comparing the webcam feed with a stored reference image.
   - As the current learning management system, Moodle monitors the exam duration and triggers automatic submission when the time expires.
   - SOAP asks the student to confirm exam submission before storing the video recording for future instructor review (Figure 6).

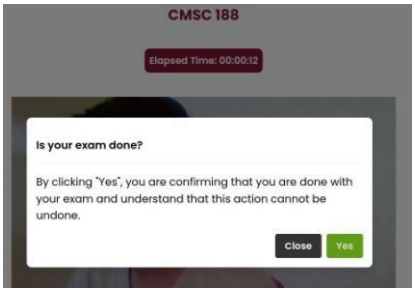


Figure 6 – Student's Exam Submission

5. Post-Exam Review:
   - Instructors use SOAP to review flagged potential cheating incidents.
   - Instructors can validate the AI analysis results and decide whether to acknowledge or override the findings, marking them as Flagged or Safe (Figure 7).

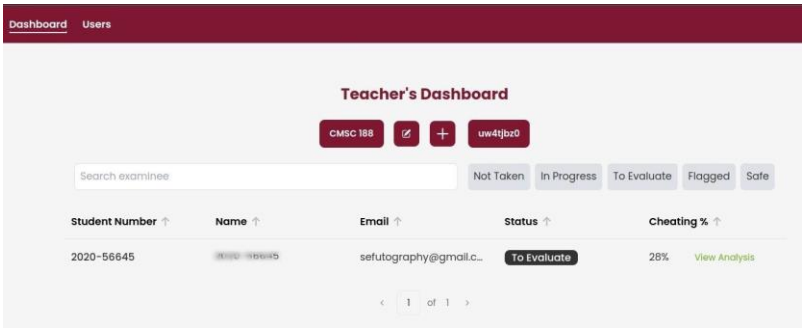


Figure 7 – Teacher's Dashboard

Phase 5 - Prototype Functional Testing

The SOAP prototype's testing phase focuses on evaluating its cheating detection accuracy. We categorized cheating incidents into four key types:

- Fake identity: This occurs when the person taking the exam is not the authorized examinee, potentially involving the use of impersonators.
- Multiple unauthorized faces: This feature detects when unauthorized individuals, such as bystanders or collaborators, are visible within the camera's field of view during the exam.
- Absence of the examinee: Triggers when the student is out of the camera's range for an extended period, signaling that the examinee is not present or has left the testing environment.

- Prohibited items: SOAP detects the presence of unauthorized materials or devices, such as cell phones, laptops, televisions, or textbooks, which are modes of cheating during the exam.

During the functional testing, the situation analysis report featured a complete video of a selected student's exam session and time-stamped logs of cheating detection events.

RESULTS AND DISCUSSION OF FEATURES

The SOAP project's main contribution lies in providing advanced capabilities for automated proctoring. We researched these technologies, then tested and integrated them into a functional prototype with the following key features:

Student Informed Consent

Privacy and user comfort were critical ethical concerns throughout the development of SOAP. Before taking the exam, SOAP advises students that by clicking the "Start Exam" button, they consent to collecting and analyzing webcam data for cheating detection. The project ensures that all collected data is handled securely and used solely to uphold exam integrity, addressing user privacy concerns and fostering trust in the system (Figure 8).

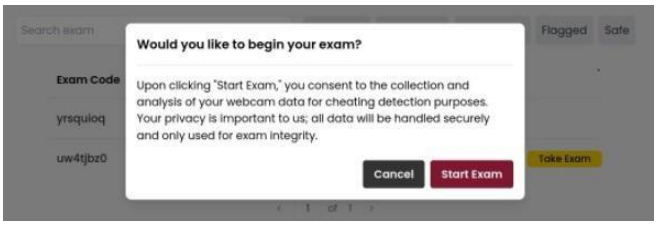


Figure 8 – Student Informed Consent

Student Face Identification

This feature ensures that only authorized students can take the exam through a combination of custom authentication methods, Google's authentication system, and dLib's face recognition technology (Geitgey, 2020). dLib compares the image from the webcam to a stored reference photo to verify the user's identity. Before the first exam, students must register by submitting a photo, which the administrator validates. Once approved, each subsequent exam undergoes face verification. Factors such as poor lighting, low-quality cameras, and varying angles can affect detection accuracy, which are some scenarios accounted for during testing.

In Figure 9, the system failed to recognize the student's face due to the inadequate angle, preventing proper facial feature capture.

Some challenges arose due to poor room lighting or low camera quality, both of which affected the resolution of the recorded video and the accuracy of detection (Figure 10).

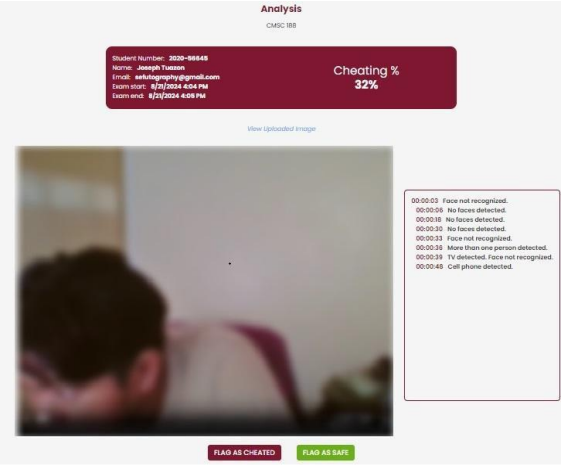


Figure 9 – Face Not Recognized

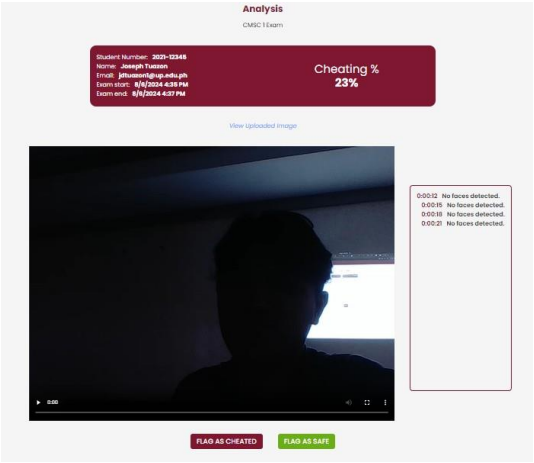


Figure 10 – Poor Room Lighting

Bystander Detection

This feature monitors whether the examinee stays within the designated exam area or leaves the webcam's view. It also detects potential collaboration with others where bystanders are identified (Figure 11). OpenCV and YOLOv3, well-known open-source libraries for computer vision, were utilized due to their efficiency in image analysis. These technologies help ensure that the examinee remains present and undistracted during the exam.

Figure 11 – Bystander Detection

Unauthorized Object Detection

Object detection recognizes unauthorized items such as cell phones, laptops, books, and televisions. The system adopts OpenCV and YOLOv3 models, which have been proven effective in identifying standard cheating devices. This feature automatically scans the video feed for prohibited objects that could compromise the examination process.

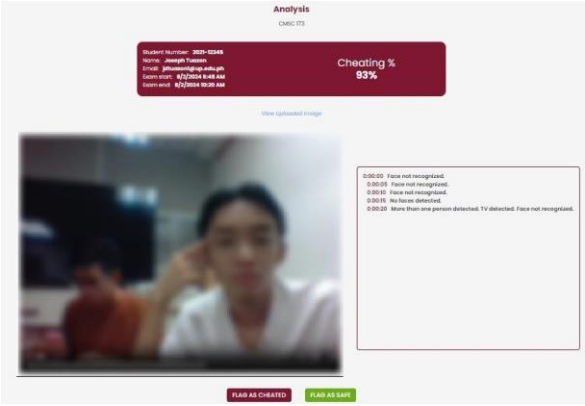


Figure 12 – Unauthorized Object Detection

Cheating Probability Calculation and Violation Reports

These features generate detailed reports that include a cheating probability score based on evidence collected during the exam, such as video snapshots and activity logs. Since the chosen libraries do not offer built-in cheating probability functionality, we developed custom algorithms to assess cheating indicators. Although these AI-generated analyses proved effective in detecting potential cheating behaviors, instructors have the final discretion to manually review the reports to verify genuine violations and reduce false alarms.

CONCLUSION AND FUTURE WORK

Overall, we have successfully developed SOAP and achieved its core objectives. The system's cheating detection mechanisms proved effective in identifying the following cases of academic dishonesty when a fake individual impersonates the examinee, when the examinee leaves their seat, and when unauthorized objects are visible in the environment.

However, specific challenges were noted during testing, primarily related to poor room lighting, low camera quality, varying angles, and unstable internet connections. These factors occasionally affected the clarity of recorded footage and the accuracy of the detection mechanisms.

Future developments could focus on refining the detection algorithms for improved accuracy, incorporating advanced techniques such as gaze tracking, head movement analysis, and speech recognition. Additionally, integrating SOAP more seamlessly with UPOU's learning management system and scaling it to support more significant numbers of users will enhance its functionality and performance. These improvements will ensure that SOAP remains a robust, resilient, and effective solution for automated exam proctoring, meeting the evolving needs of automated assessments.

REFERENCES

Arnò, S., Galassi, A., Tommasi, M., Saggino, A., & Vittorini, P. (2021). State-of-the-Art of Commercial Proctoring Systems and Their Use in Academic Online Exams. I*nternational Journal of Distance Education Technologies*, Volume 19, Issue 2, April-June 2021. https://doi.org/10.4018/IJDET.20210401.oa3

Atoum, Y., Chen, L., Liu, A., Hsu, S., & Liu, X. (2017). Automated online exam proctoring. *IEEE Transactions on Multimedia*. https://doi.org/10.1109/tmm.2017.2656064

Bhardwaj, R. (2020). Online Exam Management System Using Deep Learning. *International Journal of Creative Research Thoughts*, Volume 8, Issue 4. 2020. https://ijcrt.org/papers/IJCRT2004599.pdf

Burke, M., & Bristor, J. (2017). Academic Integrity Policies: Has Your Institution Implemented an Effective Policy? *The Accounting Educators' Journal*, 26, 1-10. http://www.aejournal.com/ojs/index.php/aej/article/view/338

Cai, X., Hu, F., & Ding, L. (2016). Detecting Abnormal Behavior in Examination Surveillance Video with 3D Convolutional Neural Networks. *2016 6th International Conference on Digital Home*. https://doi.org/10.1109/icdh.2016.014

Coghlan, S., Miller, T. and Paterson, J. (2021). Good proctor or "big brother"? *ethics of online exam supervision technologies*. Philosophy & Technology. vol 34, pp.1581–1606.

Dewar, C. (May 2023). Historical Analysis of California Community College Decisions on Whether to Adopt Online Proctoring Software During the COVID-19 Pandemic. *San Francisco State University ProQuest Dissertations Publishing*, 2023. 30524831. https://www.proquest.com/docview/2825086101/C7431E81699A4F5DPQ/8?accountid=207160&sourcetype=Dissertations%20&%20Theses

Fass-Holmes, B. (2017). International students reported for academic integrity violations: Demographics, retention, and graduation. *Journal of International Students*, 7(3). https://doi.org/10.5281/zenodo.570026

Fidas, C., Belk, M., Constantinides, A., Portugal, D., Martins, P. & et al. (2023). Ensuring Academic Integrity and Trust in Online Learning Environments: A Longitudinal Study of an AI-Centered Proctoring System in Tertiary Educational Institutions. *Education Sciences*, Basel Vol. 13, Iss. 6, (2023): 566. https://doi.org/10.3390/educsci13060566

Frank, M., Biedert, R., Ma, E., Martinovic, I., & Song, D. (2012). Touchalytics: On the applicability of touchscreen input as a behavioral biometric for continuous authentication. *IEEE Trans. Inf. Forensics Secur. 2012*, 8, 136–148. https://doi.org/10.1109/TIFS.2012.2225048

Genemo, M. (2022). Suspicious activity recognition for monitoring cheating in exams. *Proceedings of the Indian National Science Academy*, Part a, Physical Sciences, 88(1), 1–10. https://doi.org/10.1007/s43538-022-00069-2

Geitgey, A. (February, 2020). Face-recognition 1.3.0. *PyPI Blog*. https://pypi.org/project/face-recognition/

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. *MIT Press*.

Hussein, M., Yusuf, J., Deb, A., Fong, L., & Naidu, S. (2020). An Evaluation of Online Proctoring Tools. *Open Praxis*, vol. 12 issue 4, October–December 2020, pp. 509–525 (ISSN 2304-070X). https://dx.doi.org/10.5944/openpraxis.12.4.1113

ICAI (2020). Statistics overview. *International Center for Academic Integrity*, Facts and Statistics. https://academicintegrity.org/resources/facts-and-statistics

Kaddoura, S., & Gumaei, A. (2022). Towards effective and efficient online exam systems using deep learning-based cheating detection approach. *Intelligent Systems With Applications*, 16, 200153. https://doi.org/10.1016/j.iswa.2022.200153

Li, X., Chang, K.-m, Yuan, Y., & Hauptmann, A. (2015). Massive open online proctor: Protecting the credibility of moocs certificates. *In ACM CSCW*, pages 1129–1137. ACM, 2015.

Malhotra, M., & Chhabra, I. (2021). Automatic Invigilation Using Computer Vision. *Proceedings of the 3rd International Conference on Integrated Intelligent Computing Communication & Security*, ICIIC 2021.

Miguel, J., Caballé, S., Xhafa, F. and Prieto, J. (2014). Security in online learning assessment towards an effective trustworthiness approach to support E-learning teams. *Proceedings of 2014 IEEE 28th International Conference on Advanced Information Networking and Applications: IEEE AINA 2014*, pp. 123-130, 13-16 May 2014, University of Victoria, Victoria, Canada. IEEE. http://doi.org/10.1109/aina.2014.106

Mitchell, T. (1997). Machine Learning. *McGraw-Hill.*

Mohammed, H. M., & Ali, Q. (2022). Cheating Prevention in E-proctoring Systems Using Secure Exam Browsers: A Case Study. *Research Gate*. DOI: https://doi.org/10.26555/jiteki.v8i4.25094

Muzaffar, A., Tahir, M., Anwar, M., Chaudry, Q., Mir, S., & Rasheed, Y. (2021). Systematic Review of Online Exams Solutions in E-Learning: Techniques, Tools, and Global Adoption. *IEEE Access*, Volume 9. 2021. https://doi.org/10.1109/ACCESS.2021.3060192

Newton, P. (2016). Academic integrity: a quantitative study of confidence and understanding in students at the start of their higher education. *Assessment & Evaluation in Higher Education*, 41(3), 482-497. https://doi.org/10.1080/02602938.2015.1024199

Nurpeisova, A., Shaushenova, A., Mutalova, Z., Ongarbayeva, M., Niyazbekova, S., & et al (June 2023). Research on the Development of a Proctoring System for Conducting Online Exams in Kazakhstan. *Basel Vol. 11*, Iss. 6, (2023): 120. https://doi.org/10.3390/computation11060120

Osei, R. (August 2019). Automated Online Proctoring as an Alternative for Administering Online Assessments. *ProQuest Dissertations Publishing 2019*, 22619118, August 2019. https://www.proquest.com/docview/2306498281/C7431E81699A4F5DPQ/1?accountid=207160&sourcetype=Dissertations%20&%20Theses

Ozdamli, F., Aljarrah, A, Karagozlu, D. & Ababneh, M. (2022). Facial Recognition System to Detect Student Emotions and Cheating in Distance Learning. *MDPI*, Article, License CC BY 4.0. https://doi.org/10.3390/su142013230

ProctorU (2021a). A human-centered proctoring policy. https://www.proctoru.com/human-centered-proctoring

ProctorU (2021b). ProctorU to discontinue exam integrity services that rely exclusively on AI. https://www.proctoru.com/industry-news-and-notes/proctoru-to-discontinue-exam-integrity-services-that-rely-exclusively-on-ai

Rios, J., & Liu, O. (2017). Online Proctored Versus Unproctored Low-Stakes Internet Test Administration: Is There Differential Test-Taking Behavior and Performance? *American Journal of Distance Education*, 1-14. https://doi.org/10.1080/08923647.2017.1258628

Sadik, A. (2016). Factors affecting the acceptability of online degrees: Evidence from two Arab Countries. *International Journal of Emerging Technologies in Learning*, 11(12). https://doi.org/10.3991/ijet.v11i12.6022

Shute, V., & Rahimi, S. (2017). Review of computer-based assessment for learning in elementary and secondary education. *Journal of Computer Assisted Learning*, 33(1), 1-19. https://doi.org/10.1111/jcal.12172

Szeliski, R. (2010). Computer Vision: Algorithms and Applications. *Springer.*

Tiong, L., & Lee, H. (2021). E-Cheating Prevention Measures: Detection of cheating at online examinations using deep learning approach – a case study. *arXiv (Cornell University)*. https://doi.org/10.48550/arxiv.2101.09841

Slusky, L. (2020). Cybersecurity of online proctoring systems. *Journal of International Technology and Information Management*, 29(1), pp.56-83. https://scholarworks.lib.csusb.edu/jitim/vol29/iss1/3

Thomas, N. How To Use The System Usability Scale (SUS) To Evaluate The Usability Of Your Website. https://usabilitygeek.com/how-to-use-the-system-usability-scale-sus-to-evaluate-the-usability-of-your-website/

Tweissi, A., Etaiwi, W. A., & Eisawi, D. A. (2022). The accuracy of AI-based automatic proctoring in online exams: EJEL. *Electronic Journal of E-Learning*, 20(4), 419-435. https://doi.org/10.34190/ejel.20.4.2600

Zaffar, A., Jawad, M., & Shabbir, M. (2023). A Novel CNN-RNN Model for E-Cheating Detection Based on Video Surveillance. *University of Wah Journal of Computer Science*, 5, 1–13. https://uwjcs.org.pk/index.php/ojs/article/view/64

LEARNING MANAGEMENT SYSTEM FOR PROTECTION OF MARINE ENVIRONMENT COURSE: USER FEEDBACK AND STUDENT'S ACADEMIC PERFORMANCE

Aldin L. Turija[A]

ABSTRACT

This study aimed to determine the user feedback on the use of LMS (Learning Management System) for the course MarEnv (Protection of the Marine Environment). The LMS used was powered by Moodle. This study utilized survey and One Group Pretest-Posttest methods. The respondents of this study came from two Instructors teaching Mar Env, 274 third-year BSMT (Bachelor of Science in Marine Transportation) students, and the 40 intact third-year BSMT students as participants who are officially enrolled in the course MarEnv. The instruments used in the study were the students' feedback survey form and faculty feedback survey form. Both qualitative and quantitative techniques were used in the conduct of this study. The results of the survey reveal that the instructors find the LMS to be user-friendly while the students find it easy to navigate through the LMS. In the duration of the study, the students find the teaching delivery of the instructors appropriate. The assessment tools used in the LMS were easy to use and the instructions were understandable. Students' performance was Excellent based on the significant difference of the pretest-posttest mean score performances after using the LMS as an online learning tool and was found to be effective in administering lessons in MarEnv. The use of LMS is recommended to be integrated in maritime higher institutions especially for those offering distance learning.

Keywords: *learning management system, academic performance, marine environment, maritime education*

INTRODUCTION

Moodle provides educators and learners with an integrated learning platform environment that can be personalized. It is used to help students track their uploaded learning materials by their respective instructors and track their learning progress (Lungu, 2020). Moodle is the LMS provider of John B. Lacson Foundation Maritime University (Arevalo), Inc. (JBLFMU Arevalo), which helps deliver learning experiences without complexities by controlling the open-source software for the institution.

The learning platforms like moodle extend education and school management into the digital world. It delivers rich media resources also, provide collaboration tools for project work, and encourage online communication between learners and instructors (Batiduan et al., 2012). E-learning works in the maritime industry also even if the workers are required

[A] *Master in Maritime Management, Maritime Program, John B. Lacson Foundation Maritime University (Arevalo), Inc., Iloilo City, Philippines. Email: aldin.turija@jblfmu.edu.ph Orcid: https://orcid.org/0009-0008-2360-4831*

both knowledge and skills to do jobs safely and efficiently onboard ships. It does not replace hands-on training but the advantage that eLearning brings is that it provides more uniform training and an elevated discussion online (Goldberg, 2017).

Mar Env (Protection of the Marine Environment) is one of the courses in the Bachelor of Science in Marine Transportation curriculum of JBLFMU-Arevalo. The JBLFMU started to develop online platforms using moodle after threats of the 2020 pandemic and wanted to improve such modalities which were used for the continual education of the students despite the pandemic. The learning management system (LMS) developed was named JEL (JBLFMU E-Learning).

This study was conducted in response to the directives of the Chief Executive Officer of the JBLFMU through his CEO Memo 2020-028, which directs the faculty to conduct research papers for the improvement of the institution's E-learning platform and the delivery of instructions to the students.

The use of internet facilities in providing learning environments that develop collaboration and knowledge building was found in the theory proposed by Harasim (2012) called Online Collaborative Learning (OCL). The said theory was the basis of this study, where learning focuses on collaborative learning, knowledge building, and internet use as means to redesign formal, non-formal, and informal education. Since JBLFMU moved to use online platforms during the pandemic where students could not have face-to-face classes, it became a tool to deliver maritime education.

Generally, this study aimed to determine the feedback of faculty and students towards the use of moodle and the performance in the course Mar Env (Protection of the Marine Environment) during the first semester for school-year 2020-2021.

Specifically, this study aimed to answer the following questions:

1. What are the feedback of the faculty and students on the use of moodle in the course Mar Env (Protection of the Marine Environment)?
2. What is the feedback of the students on the teaching delivery using moodle for the course Mar Env (Protection of the Marine Environment)?
3. What is the feedback of the students on the teaching assessment using moodle for the course Mar Env (Protection of the Marine Environment)?
4. What are the concepts learned by the students in Mar Env (Protection of the Marine Environment)?
5. What are the pretest and posttest mean score performances of the students in Mar Env (Protection of the Marine Environment)?
6. Is there a significant difference in the pretest and posttest mean score performances of the students in Mar Env (Protection of the Marine Environment)?
7. What is the mean gain of the pretest and posttest mean score performances of the students in Mar Env (Protection of the Marine Environment)?
8. How effective is the moodle in terms of students' performance in Mar Env (Protection of the Marine Environment)?

METHODOLOGY

Research Designs

This study utilized the survey and the One Group Pretest-Posttest designs. Survey was used to get feedback from faculty and students on the use of moodle. Furthermore, students' feedback covers teaching delivery, teaching assessment, and concepts learned. One Group

Pretest–Posttest was used to determine the difference in the performance of the students taking Mar Env using the online learning as learning modality.

Respondents and Participants

The target respondents of this study came from the three Instructors teaching Mar Env selected through complete enumeration and the seven sections chosen through cluster random sampling composed of 240 third-year BSMT students. Two sections were utilized for two Instructors while three sections were utilized for one Instructor for survey. Meanwhile, a separate section composed 40 students was selected though simple random sampling for pilot-testing or reliability-testing. Furthermore, another 40 third-year BSMT students was utilized as participants for the One Group Pretest-Posttest.

Table 1 – Distribution of Respondents and Participants

Category	f	%	N	n
A. Instructors (Teaching Mar Env)	3	100	-	-
B. Third Year BSMT students (taking Mar Env)				
	-	-	590	240
Section A	40	100	-	-
Section B	40	100	-	-
Section C	40	100	-	-
Section D	40	100	-	-
Section E	38	95	-	-
Section F	38	95	-	-
Section G	38	95	-	-
C. Pilot-testing	40	100	-	-
D. One Section (One Group Pretest-Posttest)	40	100	-	-

Note. f stands for frequency, N for total population while n is the sample size.

Instruments

The instruments used in the study were the faculty and students' feedback survey forms. The open-ended questionnaire for faculty was used to collect feedbacks on the use of moodle while the open-ended questionnaire for students was used to collect feedbacks on the use of moodle, teaching delivery, teaching assessment, and concepts learned in Mar Env. These were validated by three experts in research and grammar.

Furthermore, an initial draft of 100-item multiple-choice test for the pretest/posttest was used by making first a Table of Specification (TOS). This test had undergone content validation from the three experts in a maritime course, research, and grammar and reliability-testing using the Kuder-Richardson (KR) 20 with the reliability index of 0.93. This reliability-tested questionnaire was used for the pretest-posttest to measure the academic performance of the students. It is composed of a 70-item multiple-choice type of questionnaire from the midterm coverage of the course Mar Env (Protection of the Marine Environment).

Data Collection

A feedback on the use of moodle was gathered from the instructors teaching Mar Env on the fourth week of midterm through a face-to-face approach. Also, on the fourth week of midterm, a feedback survey was sent to the student participants through Google Form. The performance of students in Mar Env was collected with the use of pretest and posttest. After content validation, this test was distributed to 40 students for reliability- testing. The students were given two hours to answer the test.

A pretest was conducted on the student participants taking Mar Env at the start of the midterm using the reliability-tested questionnaire. The intervention used was online learning using moodle as a learning modality for eight weeks. The learning platform was embedded with online activities such as online readings and quizzes, marine pollution incident case analysis, submission of topic-related memes and digital posters. The intervention using moodle comes along with a once a week online lecture using a video conferencing tool. A posttest was administered on the eighth week to measure the performance of students.

Data Analysis

Both qualitative and quantitative techniques were used in the conduct of this study. The qualitative analysis technique employed the thematic analysis. It was used to synthesize same feedbacks of the participants. In addition, frequency, percentage, and rank were applied for the feedbacks of faculty and students. Meanwhile, mean, standard deviation, t-test of dependent samples set at .05 level of significance, and Cohen's d effect size were utilized as statistical tools. A mean scale with equivalent descriptive rating and indicators for interpreting the pretest and posttest mean scores was used.

Table 2 – Mean Scale, Descriptive Rating, and Indicators for Interpreting the Pretest and Posttest Mean Scores

Mean Scale	Descriptive Rating	Indicators
56.04-70.0	Excellent	Students have mastered all the competencies
42.03-56.03	Very Good	Students have mastered most of the competencies
28.02-42.02	Good	Students have mastered at the average competencies
14.01-28.01	Fair	Students have mastered few competencies
1.0 – 14.0	Poor	Students have mastered very few competencies

RESULTS AND DISCUSSION

Among the three instructors teaching the Mar Env, two instructors gave feedback on the use of moodle. All 274 students gave feedback on their experience with moodle as a learning platform. The number of participants in the final sample who participated in the One Group Pretest-Posttest was 40 out of 40 third year BSMT students of JBLFMU (Arevalo), Inc. during the first semester of school year 2020-2021.

A. Feedback of Faculty on the Use of Moodle

One important feature of a learning platform is to be user-friendly where it should be easy to navigate through the lessons. Two instructors made a feedback that the moodle is user-friendly while 1 instructor refused to give feedback.

B. Feedback of Students on the Use of Moodle

The themes derived from the collected feedback of students regarding their usage of moodle for Mar Env are easy to use (98 answers or 36%), developer issues (73 answers or 26%), excellent and organized (67 answers or 24%) and internet connection problems (39 answers or 14%).

C. Feedback of Students on Teaching Delivery

From the feedback of students on how the course was delivered by the instructors using moodle, the themes derived are appropriate teaching style (161 answers or 52%), innovative and resourceful (65 answers or 21%), internet connection hindrances (37 answers or 12%), positive working attitude (28 answers or 9%), and not satisfactory performance (18 answers or 6%).

D. Feedback of Students on the Teaching Assessment

The themes derived from the feedback of students on the assessments in Moodle are easy and understandable (97 answers or 38%), relevant to the course (62 answers or 24%), challenging and interesting (43 answers or 17%), submission problems encountered (30 answers or 11%), and hard to answer and not clear (25 answers or 10%).

E. Concepts Learned by the Students in Mar Env

The students were asked in the questionnaire on what concepts/topics they have learned. The students have answered the following: MARPOL Annexes (215 answers or 79%), London dumping convention (42 answers or 15%) and others (14 answers or 5%).

F. Performance of Students in Mar Env

Based on the scores of the students, the pretest mean score performance was 55.78 which is described as “Very Good” and means that the students have mastered most of the competencies, that is, before the intervention. The posttest mean score performance was 63.08 is described as “Excellent” which means that the students have mastered all the competencies in Mar Env after the intervention. Furthermore, this means that the performance of the students in Mar Env has increased from pretest to posttest after using the Moodle.

Table 3 – Pretest and Posttest Mean Score Performances of the Third Year BSMT Students taking Mar Env

Test	n	Mean	Descriptive Rating	SD
Pretest	40	55.78	Very Good	9.620
Posttest	40	63.08	Excellent	4.184

Meanwhile, there is a significant difference in the pretest and posttest mean score performances of the students in Mar Env, t (39) = -5.837, p = .000. This means that after the intervention, the students significantly performed better. However, there is no comparison or control group and a lot of factors may affect the “Excellent” performance of the students in Mar Env that were not identified or considered in this study.

Table 4 – Significant Difference in the Pretest and Posttest Mean Score Performances of the Students taking Mar Env

Test	t	df	Sig.
Pretest - Posttest	-5.837*	39	.000

Note. Asterisk (*) means significant at .05 level of probability.

The mean gain of the pretest and posttest mean score performances of the students taking-up Mar Env is 7.30.

Table 5 – Mean Gain of the Pretest and Posttest Mean Score Performances of the Students taking Mar Env

Pretest Mean Score Performance	Posttest Mean Score Performance	Mean Gain
55.78	63.08	7.30

The effect size using Cohen's d is 0.836. Since the effect size is greater than 0.8, the intervention has a large effect (Cohen, 1988) as cited by Lenhard and Lenhard (2016). This means further that using the moodle as an intervention is 80% effective (Coe, 2002) in terms of improving the students' performance in Mar Env.

CONCLUSION

The instructors find the moodle to be user-friendly while the students find it easy to navigate through the moodle. In the duration of the study, the students find the teaching delivery of the instructors appropriate. The assessment tools used in the study were easy to use, and the instructions were understandable. Most of the students had remembered topics about MARPOL Annexes. From the results and discussion, this study concludes that students performance was "Excellent" based on the difference of the pretest posttest mean score performances after using the moodle as an online learning platform. It was found to be effective in administering lessons in Mar Env. However, there is no comparison or control group and a lot of factors were not considered that may affect the performance of the students.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

1. The institution may consider other options for distance learning since some students do not have stable internet connection.
2. Delegate additional personnel to address student concerns regarding errors and problems regarding the platform.
3. The institution may conduct training to instructors on innovative learning strategies to adjust to student concerns.
4. Use of online learning in other subjects by other instructors.
5. The use of online platform like moodle needs to be integrated in institutions especially for those offering distance learning to their students.
6. Conduct another study with a comparison or control group.
7. Furthermore, a follow-up study may be conducted to validate the results of this research.

REFERENCES

Batiduan, B., Gellada, L. & Pador, R. (2012). Philippine Maritime eLearning: Development, Status and Prospects. Paper presented at the *13th Annual General Assembly of the IAMU, St. John, Canada.* Retrieved from http://docplayer.net/20055914-Philippine-maritime-elearning-development-status-and-prospects.html

Coe, R. (2002). It's the Effect Size, Stupid What Effect Size is and Why it is Important. Retrieved from https://www.leeds.ac.uk/educol/documents /00002182.htm

Cohen, J., (1988). Statistical power analysis for the behavioral sciences (2. Auflage). Hillsdale, NJ: Erlbaum.

Goldberg, M. (2017). Does Elearning work in the maritime sector? Retrieved from https://www.marinels.com/elearning-work-maritime-industry/

Harasim, L. (2012). Learning theory and online technologies. *New York: Routledge/Taylor& Francis*.

Lenhard, W., & Lenhard, A. (2016). Calculation of Effect Sizes. *Dettelbach (Germany): Psychometrica*. doi: 10.13140/RG.2.2.17823.92329

Lungu, M. (2020). What is MOODLE? What are Online Learning Managements Systems? Retrieved from https://www.distancelearningportal.com/articles/161/what-is-moodle-what- are-online-learningmanagem ents-systems.html

ONEUPOU: A UNIFIED PORTAL FOR UPOU RESOURCES

Renz Jemil Magsino[A], Reinald Adrian Pugoy[B]

ABSTRACT

OneUPOU is a web-based platform designed to streamline access to University of the Philippines Open University (UPOU) resources for students and employees. The platform aggregates and organizes a comprehensive collection of UPOU-related links into easily navigable card format. Users can quickly access desired websites, copy links, bookmark cards, and adjust content display preferences such as font size and theme. OneUPOU also incorporates additional features including recent and trending link categories, a tutorial, announcements, and mobile compatibility through Progressive Web App technology. By centralizing UPOU links, OneUPOU aims to enhance user experience, improve efficiency, and serve as a valuable tool for the UPOU community.

Keywords: *Centralized Resources, Progressive Web App, Accessibility, User-friendly*

INTRODUCTION

As a pioneer institution in distance education and open learning in the Philippines, the University of the Philippines Open University (UPOU) offers quality education to students who are unable to attend traditional on-campus universities due to personal or professional constraints. In the case of open universities, where students are often geographically dispersed and come from diverse backgrounds, maintaining seamless communication and resource accessibility is paramount. UPOU operates entirely online, offering a virtual learning environment that caters to the varied needs of its students, faculty, staff, and external stakeholders. However, managing over 50 publicly accessible websites presents significant challenges in terms of navigation, information retrieval, and user experience.

Recognizing the complexities of UPOU's expansive digital ecosystem, our team developed OneUPOU, a centralized platform designed to unify all UPOU websites and microsites into a single, easily accessible hub. Launched in December 2023, OneUPOU initially offered unrestricted access to anyone. However, to ensure security and proper management, access was subsequently limited to faculty, staff, and students. Unlike the former UPOU directory, which merely listed hyperlinks, OneUPOU adopts a more informative and inclusive approach by featuring interactive cards that include website descriptions. This allows users to bookmark and categorize sites based on university offices or departments, streamlining their access to relevant information. Additionally, some cards may have restricted access tailored to specific offices or departments, ensuring that sensitive information remains secure.

[A] *Bachelor's Degree, Information and Communication Technology Development Office, University of the Philippines Open University, Laguna, Philippines. Email: renzjemil.magsino@upou.edu.ph*

[B] *Doctoral Degree, Information and Communication Technology Development Office, University of the Philippines Open University, Laguna, Philippines. Email: reinald.pugoy@upou.edu.ph Orcid: https://orcid.org/0000-0001-9683-6838*

The implementation of OneUPOU underscores the critical importance of a centralized platform in an open university setting. Such a platform not only simplifies navigation but also fosters a more integrated and cohesive digital environment, enhancing collaboration and resource sharing among all stakeholders. Accessible from anywhere, at any time, and on any device through Progressive Web App technology, OneUPOU delivers a streamlined and user-friendly experience that aligns with the flexible and inclusive ethos of open education.

To assess the effectiveness and usability of OneUPOU, a quantitative research design was employed. Data was collected using a structured questionnaire administered to the members of the Information and Communication Technology Development Office at UPOU. The questionnaire included the System Usability Scale (SUS) and the Usefulness, Satisfaction, and Ease of Use (USE) scale to measure perceived ease of use, effectiveness, usefulness, satisfaction, and overall user experience.

This paper explores the usage of OneUPOU, leveraging user access data to analyze platform utilization and effectiveness. Despite the absence of dedicated website analytics, our analysis offers valuable insights into how users interact with the platform and its impact on the UPOU community.

LITERATURE REVIEW

Alatawi et al. (2023) conducted a study to investigate factors influencing student portal usage in Saudi Arabian universities. They found that eight key factors, including ease of use, relevance of information, and technical support, significantly impact student engagement with these portals. The researchers propose a model based on these findings to guide universities in enhancing their portals and increasing student utilization. By addressing these factors, universities can improve the effectiveness of their student portals as tools for delivering teaching services and supporting student learning.

Suman (2022), highlights the significance of web directories in navigating the vast expanse of information on the internet. By organizing and categorizing websites, directories offer a valuable resource for students, researchers, and professionals seeking relevant content. It provides an overview of web directory types, features, and best practices, emphasizing their role in enhancing information retrieval and supporting academic and professional endeavors.

Thomas (2019) emphasized its limitations and utility as an indicator of overall usability. While SUS does not diagnose specific problems, scores below 68 suggest serious issues, while scores above 68 indicate reasonable usability. Thomas outlined a scoring scale where scores of 80.3 or higher are excellent, scores around 68 are acceptable, and scores below 51 warrant urgent attention. By understanding the implications of SUS scores, organizations can prioritize usability efforts and ensure a positive user experience.

Yi & Nie (2017) recognized the growing popularity of web portals in higher education but identified limitations in existing solutions. Their research addressed this gap by proposing a student-focused web portal that incorporates a multi-process web crawler. This crawler aggregates learning and entertainment resources from diverse online sources, presenting them within a unified platform. This design offers a consistent user experience with access control,

potentially enhancing student engagement by consolidating scattered information into a single, user-friendly portal.

Chakravartula (2009) proposed a system that simplifies access to event websites by providing a single source website with categorized links. This approach has the potential to enhance user experience, save time, and offer a degree of personalization. However, challenges such as maintaining a comprehensive database and addressing potential privacy concerns need to be carefully considered.

DATA AND METHODOLOGY

To gain insights into the usability of OneUPOU, a quantitative research approach was employed. A structured questionnaire combining the System Usability Scale (SUS) and the Usefulness, Satisfaction, and Ease of Use (USE) scale was utilized to collect data. These tools were used to capture key aspects of user experience, including ease of use, effectiveness, usefulness, and overall satisfaction with the platform.

The target population was specifically limited to the team members of the ICT Development Office at the University of the Philippines Open University as they were the primary users involved in the platform's integration with another application. Given the specific nature of the platform and its intended operational context, limiting the sample to this group ensured that the data collected would be relevant and reflective of actual user interactions.

An online survey was distributed to all team members, with participation being voluntary and confidentiality assured. The questionnaire assessed participants' perceptions of OneUPOU's ease of use, effectiveness, usefulness, satisfaction, and overall user experience. Data analysis involved descriptive statistics to summarize the data, inferential statistics to identify significant differences or relationships, and correlation analysis to examine the connections between variables.

Ethical considerations were strictly adhered to throughout the study. Participants were provided with informed consent, and their data was handled anonymously to maintain confidentiality. The study also received approval from the relevant ethics committee or institutional review board.

RESULTS AND DISCUSSION

The quantitative analysis of OneUPOU's usability among the ICT Development Office team at UPOU yielded positive results, reflecting the platform's strong performance in terms of user experience. Out of the eight respondents who completed the survey, all had personal experience using OneUPOU. The platform achieved a SUS score of 81.25, significantly surpassing the global median of 68 (Thomas, 2019). This places OneUPOU in the category of acceptable and good usability, equivalent to a grade scale of B, indicating that users generally find the platform effective and easy to use.

Analysis of the SUS questionnaire revealed that users frequently utilize OneUPOU, primarily due to its intuitive, card-based navigation system. The platform's intuitive design

allows users to easily locate and access the relevant UPOU websites and microsites, eliminating the need for external support as users can easily learn and utilize its features independently. However, there were mixed responses regarding the platform's complexity, with some users finding it unnecessarily complex. Thus, there may be opportunities to streamline certain functions to accommodate varying user preferences.

Furthermore, all responses to the USE questionnaire scored above average, indicating that OneUPOU is perceived as useful, efficient, simple, friendly, and easy to understand. Users particularly appreciated the platform's bookmarking feature, which allows them to save frequently accessed websites, enhancing productivity by minimizing search time. Additionally, respondents praised the platform's mobile compatibility, facilitated by Progressive Web App technology, which provides flexibility and ease of use across different devices. Moreover, users found OneUPOU's simplicity and available instructional videos highly beneficial. These features reduced the learning curve, making the platform accessible even to those less familiar with web technologies. Overall, the platform's design, coupled with these supportive resources, contributed to a smooth and efficient user experience.

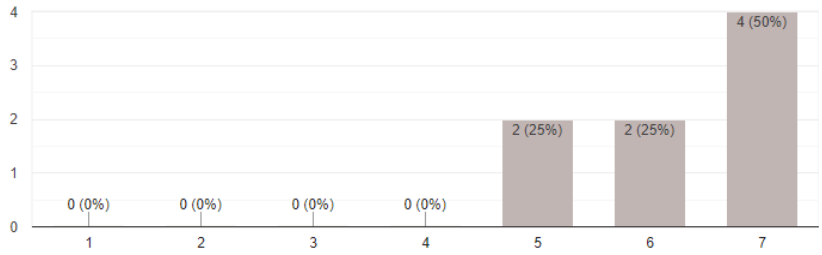


Figure 1 – Usefulness Score

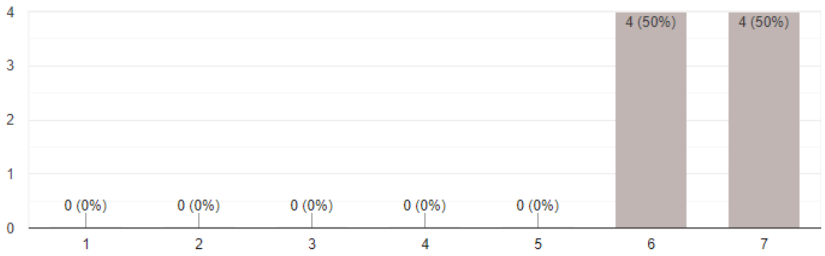


Figure 2 – Ease of Use Score

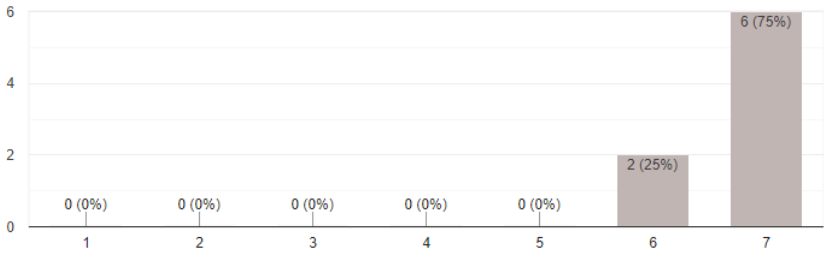


Figure 3 – Ease of Learning Score

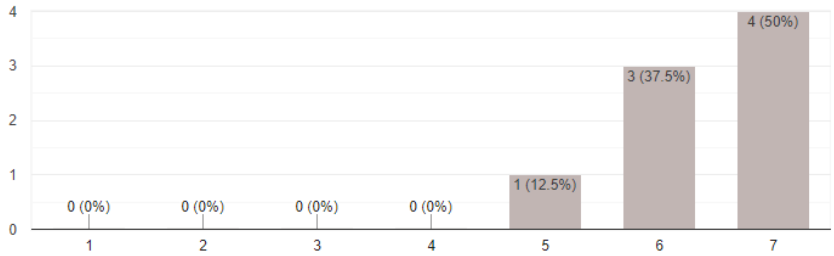


Figure 4 – Satisfaction Score

Despite these positive findings, participants provided feedback on areas for improvement. Several respondents commented that the platform's user interface (UI) appeared outdated, lacking the modern aesthetic seen in contemporary web designs. To enhance OneUPOU, it is recommended to modernize the user interface and implement private cards for users to save and organize their own links. This feature would further personalize the user experience and allow individuals to customize the platform to meet their unique needs, making navigation even more efficient. By addressing these recommendations, OneUPOU can further improve its user experience and meet the evolving needs of its users.

CONCLUSION

OneUPOU has proven to be a valuable tool for the ICT Development Office at UPOU, providing a centralized and organized platform for accessing essential university resources. By consolidating frequently used links into an intuitive, card-based interface, OneUPOU enhances user efficiency, making navigation simpler and more convenient for team members.

While the study focused on the ICT Development Office, the findings suggest that OneUPOU has the potential to benefit a broader range of UPOU users. Future research could explore the platform's usability and impact on other user groups within the university.

However, the platform is not without its limitations. Link creation is currently restricted to the platform's management team, which can potentially slow down the addition of new links. Automation could be further explored to streamline the process of adding and updating link cards. Additionally, integrating password management into OneUPOU would enhance security and convenience for users.

Despite these limitations, OneUPOU demonstrates significant potential for improvement. Future research could focus on exploring automation techniques, password management integration, and user feedback to identify areas for enhancement. By addressing these limitations and leveraging user insights, OneUPOU can become an even more indispensable tool for both UPOU and other organizations with a large number of links to manage.

REFERENCES

Alatawi, S.S.T., Miskon, S., Abdullah, N.S., Ghabban, F., Saeed, F., Alfadli, I. and Ameerbakhsh, O. 2021. A New Model for Enhancing Student Portal Usage in Saudi Arabia Universities. Engineering, Technology & Applied Science Research. 11, 3 (Jun. 2021), 7158–7171. DOI: https://doi.org/10.48084/etasr.4132

Suman, Anubhaw & MGCUB, Patel,. (2022). Web Directories: A Searching Tool.

Thomas, N. (2019). How to use the System Usability Scale (SUS) to evaluate the usability of your website. Usability Geek. https://usabilitygeek.com/how-to-use-the-system-usability-scale-sus-to-evaluate-the-usability-of-your-website/

Haibo, Yi, and, Zhe, Nie. (2017). Building an Efficient Web Portal for Students at Institutions of Higher Education Based on Web Crawlers. doi: 10.23977/ICCSC.2017.1016

Binaymin, Sami & Rutter, Malcolm & Smith, Sally. (2016). The Utilization of System Usability Scale in Learning Management Systems: A Case Study of Jeddah Community College. 5314-5323. 10.21125/iceri.2016.2290.

Sauro, J., PhD. (2011). Measuring Usability with the System Usability Scale (SUS) – MeasuringU. https://measuringu.com/sus/

Vasanta, Madhavi, Chakravartula. (2009). Selecting and routing of different event websites from one source website.

Lund, Arnold. (2001). Measuring Usability with the USE Questionnaire. Usability and User Experience Newsletter of the STC Usability SIG. 8.

Brooke, John. (1995). SUS: A quick and dirty usability scale. Usability Eval. Ind.. 189.

BEYOND WRITTEN PAPERS: HARNESSING VIDEO PRESENTATION FOR ENHANCED ASSESSMENT IN ONLINE LEARNING

Tricia C. Ascan[A], Angelo Joaquin C. Ascan[B]

ABSTRACT

Traditional written papers are often used as the primary mode of assessment in online learning environments. However, incorporating video presentations as an assessment tool can significantly enhance the evaluation process. Video presentations can provide an audio-visual medium for assessing students' knowledge, allowing for the evaluation of learning outcomes and the ability to convey ideas effectively, think critically, and engage an audience. This paper explores how using video presentations in online and distance learning courses can offer a more dynamic and engaging medium for students to demonstrate their knowledge, creativity, and communication skills. Moreover, video presentations encourage students to develop essential 21st-century skills, such as digital and media literacy, which are increasingly valuable in today's digitally-driven world. The paper used a qualitative method approach and data was gathered from students enrolled in the undergraduate, graduate, and non-formal course levels that utilized video presentation as their final assessment. This study examines best practices for integrating video presentations into online courses and offers practical guidelines for educators seeking to enhance their assessment methods beyond traditional written assignments.

Keywords: *Video Presentation, Assessment, Online Learning, Online Courses*

INTRODUCTION

Traditional written papers have been the norm in student assessment. They are considered as the one of the standard methods for gauging student understanding of the learning materials. However, limitations of this format are becoming increasingly apparent, particularly in an online learning environment. Despite the increasing integration of technology in education, traditional assessment methods, such as written papers, often fail to fully engage students or accurately reflect their understanding and skills in online learning contexts. MacAndrew and Edwards (2002) noted an increasing concern in giving traditional essay assignments as they are susceptible to plagiarism and are very time-consuming to mark. Written assignments usually could not capture the full range of student abilities, such as oral communication, creativity, and the practical application of knowledge. Dikli (2003) provided

[A] *Master of Management in Agribusiness Management, Faculty of Management & Development Studies, University of the Philippines Open University, Laguna, Philippines. Email: tascan@upou.edu.ph*
[B] *Bachelor of Arts in Multimedia Studies, Center for Open and Digital Teaching & Learning, University of the Philippines Open University, Laguna, Philippines. Email: angelojoaquin.ascan@upou.edu.ph*

a comparison between traditional and alternative assessments, especially within the context of distance education. She argued that traditional assessments such as true or false, multiple choice, etc. assess only lower-order thinking skills and are usually time-constrained. The author then suggested several alternative methods such as portfolios, projects, and performance-based tasks that are more authentic and involve higher-order thinking skills.

Online and distance learning offers opportunities for developing authentic assessments and alternative evaluation activities. Advancements in technology further expand possibilities for authentic assessments, incorporating tools like social media alongside traditional methods such as essays and reports (Conrad & Openo, 2018). One alternative is the use of video presentations. Video presentations offer a unique opportunity for students to demonstrate their knowledge and skills in a more dynamic and interactive manner (Groth, 2022). They can display students' ability to communicate, engage an audience, and hone their skills in using digital tools to convey their message. They can capture nuances such as tone, emotion, and body language, which are not seen in a written work. Moreover, this type of assessment also encourages creativity, as students are challenged to think critically about how to convey their ideas using visual and auditory elements (Anmary & Mohammed, 2022).

What happens when you incorporate video presentations into an assessment in online and distance learning? This study aims to explore the use of video presentations in assessing student learning in an online learning environment. The study also seeks to determine the perceived benefits and challenges of creating and presenting videos as a form of assessment.

Research Objectives

This paper explores how using video presentations in online and distance learning courses can offer a more dynamic and engaging medium for students to demonstrate their knowledge, creativity, and communication skills. Specifically, the research aims to:

1. Describe how video presentations are utilized as an assessment tool in online learning environments across various courses in different academic programs.
2. Document the experiences, perceived benefits, and challenges faced by students in creating and presenting videos.

LITERATURE REVIEW

Several studies have been conducted regarding the use of videos in student assessment. The current trend of online video content has transformed the medium into one of the most promising instruments for teaching and learning. Andrist et al. (2014) introduced a video pedagogy that categorizes various types of videos that can assist educators in selecting the most appropriate video type to align with specific learning and assessment goals. During the Covid-19 pandemic, transitions to online assessment became inevitable. Innovative assessment tools were needed to cover required competencies and video presentations were utilized. In a study conducted by Amin, et.al. (2021), case-based learning was introduced to medical students along with the task to create videos as a final summative assessment module. This integration allowed students to articulate their understanding of clinical concepts through a medium that promotes creativity and engagement. The results showed an overwhelming approval of the video presentation approach with many students expressing a desire for this method to replace traditional assignments. This indicates that they found the experience motivating and beneficial for their learning. Anmary and Mohammed (2022) on the other

hand, explored how video presentations can support students learning English as a Second Language (ESL) in achieving their learning objectives. They found that this approach helps build stronger oral presentation skills as ESL students can watch themselves speak and reflect on their performance, improving self-assessment and confidence. Moreover, students noted a sense of learning autonomy which encourages creativity and active engagement as they manage and organize their content. The study then proposed a conceptual model that links video presentations to academic achievement in ESL contexts through key factors like understanding, creativity, and communication skills. In another study by Gupta et al. (2023), undergraduate Computer Science students produced video content to explain their database design for a given case study during the Covid-19 pandemic. The videos were then published on YouTube and likes were incorporated as part of the assessment, making the grading process more transparent. It also encouraged peer learning by allowing students to view and learn from the videos of other groups. While some students struggled with public speaking, video editing, group collaboration, and meeting deadlines, the students appreciated the innovative assessment method and suggested its continuation and further improvement. Lastly, an empirical study by Zarb & Birtleskelman (2020) provides evidence that video-based assessments can reduce student stress, enhance creativity, and align with professional expectations.

The literature highlights the growing adoption of video presentations as an innovative and effective tool for student assessment, particularly in online learning environments. Video-based assessments allow students to show their understanding through creative means while developing essential skills like communication, self-reflection, and autonomy. While challenges such as public speaking anxiety, video editing skills, and group dynamics were noted, the overall feedback suggests that video presentations offer a promising alternative to traditional assessment methods, especially in promoting active learning and peer collaboration.

Conceptual Framework

Two learning theories were the basis of this study. One is the Multimedia Learning Theory by Richard Mayer in 2001. This theory suggests that people learn more effectively from a combination of words and pictures than from words alone. This theory underpins the idea that integrating various multimedia elements such as visuals, narration, and text can enhance the learning process by engaging multiple cognitive channels. Video presentations leverage both the visual and auditory processing systems, leading to better retention and understanding of the material. This framework supports the argument that video presentations can be a more effective assessment tool compared to traditional written papers, as they allow students to demonstrate their knowledge using a richer, more engaging medium.

Another theory is the Constructivist Learning Theory which was introduced by Piaget (1964). This theory highlights the importance of active engagement and reflection. Creating a video presentation requires students to actively engage with the content, organize their thoughts, and make decisions about how best to convey their message. This process is aligned with constructivist principles, which emphasize the role of learners in constructing their knowledge. Moreover, the creative process of developing a video presentation encourages deeper understanding and personal connection to the material, as students must not only grasp the content but also consider how to communicate it effectively to an audience.

The figure below represents the conceptual framework that were used in this study:

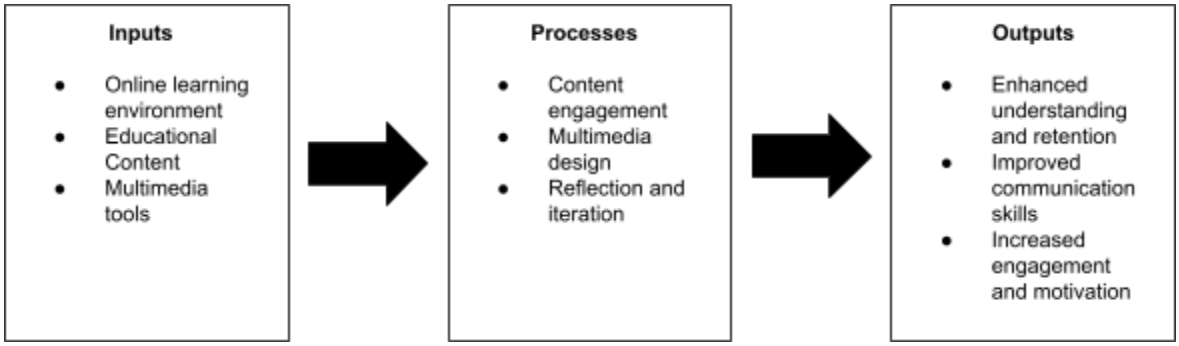


Figure 1 – The Conceptual Framework

The conceptual model revolves around the integration of multimedia tools in an online learning environment to enhance students' understanding, retention, and communication skills. The online learning environment serves as the platform where educational activities and assessments occur, while the educational content represents the subject matter that students must comprehend and convey. To present their knowledge, students use multimedia tools, such as video editing software and graphic design tools, which provide the resources to create engaging video presentations.

The processes involved in this model are grounded from the two learning theories. Through content engagement which is aligned with Constructivist Theory, students actively interact with the educational material, organizing it into a coherent narrative that forms the basis of their video presentation. Next, as they design their presentations using a combination of visual, auditory, and textual elements, they follow the principles of Multimedia Learning Theory, which states that such integration enhances cognitive processing and knowledge retention. Finally, the process involves reflection and iteration where students refine their work and reflect on their learning. This leads to a deeper understanding of the topic they are learning.

The outputs of this model include enhanced understanding and retention of the subject matter by the students. Additionally, the process of creating and presenting videos improves their communication skills, especially in oral communication and digital literacy. Lastly, the creative and interactive nature of video presentations leads to increased engagement and motivation, as students become more invested in the learning process through the active and personalized creation of multimedia content.

DATA AND METHODOLOGY

This study employed a descriptive qualitative approach to provide an account of the experiences, perceptions, and challenges encountered with the preparation and presentation of videos as an assessment tool. Purposive sampling was done from the three batches of course enrollees from different program levels.

Data collection

Students enrolled in three particular courses from different programs and levels participated in this study. The undergraduate participants consisted of students enrolled in ENT 102 (Legal Environment, Integrity & Accountability) under the Associate of Arts in Digital Entrepreneurship Program (AADE). Participants at the graduate level were from PM259 (Special Topics: Interlocal Cooperation) under the Master of Public Management Program

(MPM). Lastly, non-formal learners enrolled in the Personal Entrepreneurial Development (PED) course under the Continuing Education Program (CEP) also participated in the study. All these programs are under the Faculty of Management and Development Studies of the University of the Philippines Open University.

Table 1 – Program and Participants

Program	Course	Level of Program	Period	Number of Enrolled Students
Associate of Arts in Digital Entrepreneurship	ENT102	Undergraduate	3rd Trimester 2023-2024	8
Continuing Education Program	PED	Non-formal	2nd term 2024	17
Master of Public Management	PM259	Graduate	2nd Semester 2023-2024	16

Source: Prepared by the authors (2024)

After the live meeting or submission of a recorded video presentation, students were asked to reflect on their experiences in preparing, recording, and presenting the video by answering questions from a Google form.

Data analysis

Key themes related to student experiences, perceptions, and challenges of video presentations were identified and categorized.

RESULTS AND DISCUSSION

As part of the course requirements, students in ENT 102 were tasked to prepare and present a video presentation which they presented during a scheduled live meeting. For graduate students of PM259, they were given the option to submit a recorded video presentation to upload in UPOU's Learning Management System called MyPortal since most of them were working and could not attend a live session. PED students were also required to submit a recorded video with the option to present during the live meeting. Assignment guides were given to each course with specific instructions on the required tasks. Grading was based on the rubric provided in the assignment guide.

Video Presentation as an Assessment Tool

a. ENT 102

For ENT 102, their final project involved a case analysis on business ethics. The students were grouped into two and they were given two case studies to analyze. Instructions include preparing two written case analysis and two video presentations. A scheduled live presentation was done during the last week of the trimester. Each group assigned one presenter for each case. The groups were given 15 minutes to present, after which a case discussion followed with the group taking turns to question each other. Peer evaluation was also done using a rubric provided to the students. These were the screenshots of the outputs of each group.

Group 1: iskoMPASSIONATE

Group 2: P2K (Promise 2 Keep)

Figure 2 – Outputs of ENT 102 groups

b. Personal Entrepreneurial Development (PED)

For PED, one of the assignments is to submit a recorded video presentation about their Personal Entrepreneurial Competencies (PEC) results. It has the following instructions:

a. Answer Activity 5 and accomplish the PEC profile sheet.
b. Summarize the results and present a short video presentation describing your experience about the process.
c. Your video presentation should be no more than 10 minutes long.
d. Your video presentation should be in mp4 format.
e. Upload your video in Google Drive and share the link in the assignment bin in the course site.

The following were some of the screenshots of the outputs from PED students.

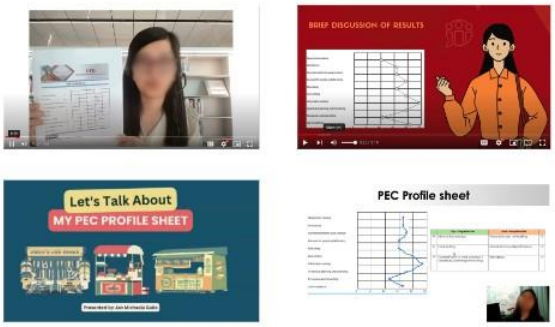


Figure 3 – Outputs of PED students

c. PM259

There were three sets of assignments that utilized video presentation under PM259. The students were grouped into six and they were tasked to (1) prepare an interlocal cooperation roadmap, (2) analyze the institutional ingredients of an alliance, and (3) analyze the financial ingredients of an alliance. They were given assignment guides for each task, explaining the instructions for answering them. Then, they were asked to prepare a summary

report in PowerPoint or Canva presentation with narration. The summary should be in mp4 format and not more than 10 minutes long. Assignments were then uploaded to Google Drive and the links were submitted in the submission bins in MyPortal.

Screenshot outputs of each group are presented below.

Figure 4 – Outputs of PM259 groups, Team 4A and SynerJ

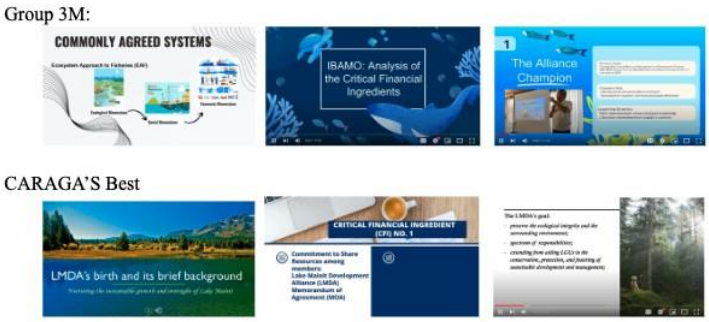


Figure 5 – Outputs of PM259 groups, Group 3M and CARAGA'S Best

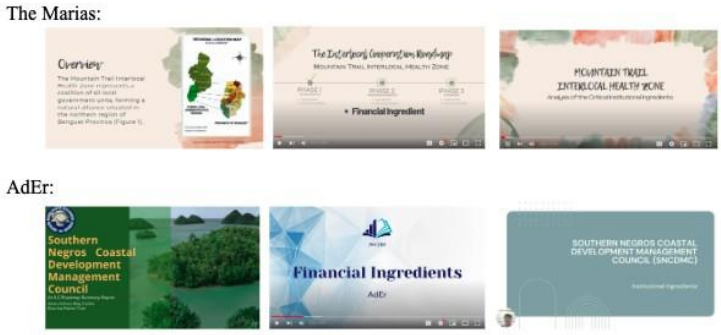


Figure 6 – Outputs of PM259 groups, The Marias and AdEr

Experiences, Perceptions, and Challenges of Video Presentation

When asked to describe their experiences in preparing their video presentations, the majority of the students found them to be engaging compared to traditional assignments. They claimed it has helped them understand the topics better and improve their comprehension of the learning materials. They were also able to express their ideas creatively. This suggests that video presentations are effective in increasing student engagement with the course materials and is consistent with Mayer's multimedia learning theory. Some of the comments include:

"I find the [video] recording very helpful because it is like a summary of our topics captured within that specific episode [topic]. Also, I am grateful that we were grouped in making our assignments because this way… we work together to finish our tasks."

"The format of the assignments were extremely helpful in understanding the lessons. It has compelled me to understand and analyze the lessons by reading the course materials, do[ing] extensive research, and apply[ing] all the learnings."

"Compared to traditional presentations, such as essays or written reports, video presentations are a great way to deliver a message. They may be short, but they are easier to digest than blocks of text. Videos serve as summarized versions and are also entertaining to watch, with all the visuals presented."

We were able to understand the case better. Despite being lengthy, the videos were helpful in conveying the message to viewers. We were receptive enough to absorb the insightful information.

Students also mentioned that creating video presentations helped them develop skills particularly creativity and digital literacy. The most common tool that they use is Canva and smartphone cameras. They saw it as a way to practice their skills in using presentation tools and video editing. Additionally, they also reported that it helped them in improving their communication and presentation skills during the live presentation. However, confidence levels were mixed, as one reported that it was her first time to create a video presentation and with limited tools.

"I find it really easy to prepare and create a video presentation. However, it requires creativity and time to produce the video in the most artistic way possible."

"It was my first time to create a video presentation and I'm happy with the outcome since I was able to make a skit/script and design of my presentation."

Some of the challenges faced in preparing video presentations include the length of time it takes to create one, difficulty in expressing their ideas, and performance anxiety. The time investment required to create video presentations was considerable, with many students spending between 5 to 10 hours on the task. Another is limited access to video editing tools. One student mentioned stuttering issues and therefore has anxiety when recording her voice.

"One issue I have faced in submitting video presentations [is] the file size in the submission bins. Secondly, another issue I face is I tend to study video editing while juggling the other parts of video creation— this puts me at a time constraint to deliver the material whilst going in blind with editing video presentations as I [also have] limited access to video editing software that meets my needs."

Finally, while students appreciated the video format, preferences varied, with others still favoring traditional written assignments.

> *"I'm more inclined to express myself in a written way but I understand that if video assessments are normalized in the near future, I'll see it as an opportunity to broaden my horizon and skill sets."*

> *But [I'm] really not a fan of video presentations, [I] prefer written reports because that's where [I] think [I'm] really good at and [I] can express more thoughts and ideas through it.*

CONCLUSION

This study reveals several insights into students' experiences and perceptions regarding the use of video presentation as an assessment tool. The findings suggest that it offers opportunities for students to actively engage in the learning process, while at the same time develop their digital literacy and communication skills. Despite some challenges, video presentations can be utilized by educators to better support student learning in an online learning environment. Further research could look into various strategies for effectively integrating video presentations in online classes. Additionally, a study on the long-term impact of video presentations on skill retention and academic performance may be explored.

REFERENCES

Amin, H. a. A., Khalil, H., Khaled, D., Mahdi, M., Fathelbab, M., & Gaber, D. A. (2021). Case item creation and video case presentation as summative assessment tools for distance learning in the pandemic era. *Medical Journal Armed Forces India*, 77, S466–S474. https://doi.org/10.1016/j.mjafi.2021.05.018

Andrist, L., Chepp, V., Dean, P., & Miller, M. V. (2014). Toward a Video Pedagogy: A Teaching Typology with Learning Goals. *Teaching Sociology*, 42(3), 196–206. http://www.jstor.org/stable/43186581

Anmary, A. S., & Mohammed, L. A. (2022). The effect of video presentation on achieving academic performance among ESL students in Malaysia. *International Journal of Emerging Issues in Social Science Arts and Humanities*, *01*(01), 52–56. https://doi.org/10.60072/ijeissah.2022.v1i01.005

Conrad, D., & Openo, J. (2018). Assessment strategies for online learning: Engagement and Authenticity. *AU Press.*

Cotter, M., & Hinkelman, D. (2019). Video assessment module: self, peer, and teacher post-performance assessment for learning. In F. Meunier, J. Van de Vyver, L. Bradley & S. Thouësny (Eds), CALL and complexity – short papers from EUROCALL 2019 (pp. 94-99). *Research-publishing.net*. https://doi.org/10.14705/rpnet.2019.38.992

Dikli, S. (2003). Assessment at a Distance: Traditional vs. Alternative Assessments. ˜ *The Turkish Online Journal of Educational Technology*, 2(3), 13–19. http://files.eric.ed.gov/fulltext/EJ1101956.pdf

Groth, C. (2022). Video as a tool for knowing and telling in practice-led craft research. In *Acta Universitatis Gothoburgensis eBooks* (pp. 48–66). https://doi.org/10.21524/kriterium.40.c

Gupta, S., Tomar, S., & Gupta, A. (2023). Learner-generated YouTube presentations for formative assessment. *STEM Education*, 3(4), 306–330. https://doi.org/10.3934/steme.2023019

MacAndrew, S.B., & Edwards, L. (2002). Essays are not the only way: A case report on the benefits of authentic assessment. *Psychology Learning and Teaching*, 2(2), 134-139. https://journals.sagepub.com/doi/pdf/10.2304/plat.2002.2.2.134

Mayer, R. E. (2001). Multimedia Learning. United Kingdom: Cambridge University Press. Piaget, J. (1964). Part I: Cognitive development in children: Piaget development and learning. *Journal Research in Science Teaching*, 2(3), 176–186. doi: 10.1002/tea.3660020306

Zarb, M. and Birtleskelman, J. (2020). Through the lens: enhancing assessment with video-based presentations. In Proceedings of the 25th Association for Computing Machinery (ACM). *Innovation and technology in computer science education conference 2020 (ITiCSE '20)*, 15-19 June 2020, Trondheim, Norway. New York: ACM [online], pages 187- 192. Available from: https://doi.org/10.1145/3341525.3387376.

GENERATIVE ARTIFICIAL INTELLIGENCE (GENAI) TOOLS IN TEACHING ENGLISH COMMUNICATION SKILLS

Tiptida Bootchuy[A], Patthanan Bootchuy[B]

ABSTRACT

Integrating artificial intelligence (AI) technologies in education has shown remarkable potential in revolutionizing various aspects of teaching and learning. Generative artificial intelligence (GenAI) tools are revolutionizing how educators approach content creation, and personalized learning, and have impacted school education in numerous ways. However, most of the discussions occur in higher education. This study examines the integration of Generative Artificial Intelligence (GenAI) tools in teaching English communication skills. As language learning continues evolving with technological advancements, GenAI presents opportunities and challenges for educators and learners alike. This study examines the current landscape of GenAI applications in English language teaching, their potential benefits, functionalities, ethical considerations, and their effectiveness in enhancing teaching capabilities across all four skills. Through comprehensive literature, we aim to provide insights into the effective integration of GenAI tools in English communication skills: listening, speaking, reading, and writing.

Keywords: *Generative artificial intelligence, GenAI, English Communication Skills*

INTRODUCTION

Integrating Generative Artificial Intelligence (GenAI) tools into education has transformed how teachers and learners approach learning, particularly in teaching English communication skills. GenAI tools, built on advanced machine learning models, enable dynamic content creation, personalized learning experiences, and enhanced interaction between learners and instructors. Research by Chen (2024) indicates that GenAI tools assist learners in improving vocabulary, pronunciation, and comprehension more engagingly than traditional methods. Beyond conversational practice, GenAI supports personalized learning by simplifying complex texts, generating tailored lesson plans, and providing individualized feedback (Van den Berg, 2024). This adaptability is particularly beneficial in open and distance learning environments, where students can engage in critical thinking exercises and develop higher-order communication skills. However, the effective implementation of GenAI in educational settings necessitates clear institutional policies to address ethical concerns and ensure consistent application (Szabó & Szoke, 2024).

[A] *MA. in English for Specific Purposes, English Program, Phetchaburi Rajabhat University, Phetchaburi, Thailand. Email: tiptida.boo@mail.pbru.ac.th Orcid: https://orcid.org/0009-0008-4747-3020*

[B] *Ph.D. in Educational Technology and Communications, Office of Educational Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: patthananb@hotmail.com Orcid: https://orcid.org/0009-0002-3428-8121*

Despite the advantages, adopting GenAI in ELT presents challenges, including potential biases in AI-generated content and the risk of over-reliance on technology. Educators and students have expressed concerns regarding the accuracy and ethical implications of using AI tools in language learning. Studies applying the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) highlight the need for regulatory frameworks to guide the ethical use of GenAI, particularly in assessments and assignments (Chatterjee & Bhattacharjee, 2020; Bozkurt, 2023). This study examines the integration of GenAI tools in teaching English communication skills, focusing on their functionalities, benefits, and ethical considerations. By analyzing current literature, we seek to provide insights into effectively incorporating GenAI in ELT to enhance listening, speaking, reading, and writing skills. As language education continues to evolve with technological advancements, understanding the implications of GenAI is crucial for educators and learners alike.

LITERATURE REVIEW

A comprehensive literature review was conducted to understand the current landscape of GenAI applications in teaching English communication skills in higher education, focusing on the four key skills: listening, speaking, reading, and writing.

The challenges of teaching English communication skills in the age of generative artificial intelligence.

The advent of Generative Artificial Intelligence (GenAI) has significantly impacted the teaching of English communication skills, presenting both opportunities and challenges. GenAI tools, such as ChatGPT, have been integrated into English Language Teaching (ELT) to enhance learning experiences. Bozkurt (2023) highlights that these tools facilitate conversational practice, aiding in the development of speaking and listening skills. Similarly, Pack and Maloney (2023) discuss the potential of GenAI in creating language learning materials and assessments, emphasizing its role in personalized learning. However, the integration of GenAI in ELT is not without challenges. Chatterjee and Bhattacharjee (2020) apply the Technology Acceptance Model (TAM) to study educators' and students' perceptions of AI in education, revealing concerns about accuracy, biases, and over-reliance on AI-generated content. These concerns are echoed by McKnight and Shipp (2024), who question the ethical implications of using GenAI as a writing tool, suggesting that it may undermine the development of authentic writing skills.

Moreover, the rapid advancement of GenAI technologies has led to technostress among educators. Bozkurt (2023) explores this phenomenon, noting that the continuous need to adapt to new technologies can affect teachers' psychological well-being. This is particularly relevant in the context of English language education, where the pressure to integrate GenAI tools effectively can be overwhelming. In addition to ethical and psychological challenges, there are practical concerns regarding the implementation of GenAI in ELT. Lee and Maeng (2023) investigate high school students' perceptions of AI chatbots in English learning, identifying benefits such as increased engagement and personalized feedback, but also concerns about the accuracy and appropriateness of AI- generated responses. These findings suggest that while GenAI has the potential to enhance English communication skills, its effectiveness is contingent upon careful implementation and ongoing evaluation.

The benefits of integrating generative AI in English language teaching

Integrating Generative AI (GenAI) into English Language Teaching (ELT) brings several valuable benefits that enhance learning outcomes and engagement. These advantages span across personalized learning, improved access to resources, enhanced communication skills, and support for critical thinking.

1) Enhanced Communication Practice: GenAI applications such as ChatGPT enable conversational practice in English by simulating dialogues, making it a powerful tool for enhancing students' speaking and listening skills in realistic contexts. Studies have shown that these tools assist students in improving vocabulary, pronunciation, and comprehension more engagingly than traditional methods. (Bozkurt, 2023) The studies emphasize that effective prompt engineering—structuring questions and commands for the AI—can significantly enhance the learning experience, aligning with emerging digital literacy needs in language education.

2) Personalized Learning and Teacher Support: Teachers increasingly use GenAI to simplify complex English texts, generate lesson plans, and provide personalized feedback to students, especially in open and distance learning environments. This support extends to critical thinking exercises, where students use GenAI to generate and evaluate ideas, thereby developing higher-order thinking skills essential for communication. However, the need for clear institutional policies remains critical, as the lack of guidelines can lead to ethical concerns and inconsistency in application. (Van den Berg, 2024)

3) Classroom Integration and Engagement: GenAI tools like ChatGPT, DALL-E, and other chatbots are widely used to generate conversational practice, role-playing scenarios, and content creation tasks, enhancing student engagement. These tools also enable English Language Teaching (ELT) by helping students with vocabulary acquisition, grammar practice, and topic discussion, thus fostering critical thinking and digital literacy (Fruzsina Szabó, Joanna Szoke, 2024)

4) Accessibility and Self-Learning: GenAI tools are highlighted for promoting autonomous learning, allowing students to practice outside the classroom, which can be especially helpful in remote and hybrid learning environments. The research underscores the self-directed use of GenAI as beneficial for varied proficiency levels, although support from instructors is essential to maximize tool effectiveness. (Bradley Irwin, 2024)

5) Implications for Ethical and Responsible Use: The Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) have been applied to study educators' and students' perceptions of GenAI, highlighting factors such as perceived ease of use, effectiveness, and ethical concerns. While many educators appreciate GenAI's utility, concerns about accuracy, biases, and dependency on AI indicate a need for regulatory frameworks to guide ethical use, especially for assignments and assessments. These frameworks are crucial in mitigating risks associated with over-reliance on AI-generated outputs (Chatterjee & Bhattacharjee, 2020; Bozkurt, 2023).

Generative AI tools, enhance English language learning by fostering conversational skills, personalized feedback, and self-directed learning, especially in hybrid settings. While they support critical thinking and engagement, clear policies are needed to manage ethical concerns and reliance on AI. Effective prompt engineering is crucial for maximizing these tools' educational potential.

The ethical considerations of integrating generative AI in English language teaching

The integration of Generative Artificial Intelligence (GenAI) in English Language

Teaching (ELT) offers significant potential for enhancing educational outcomes. However, it also raises several ethical considerations that educators and institutions must address to ensure responsible use.

1) Academic Integrity and Authenticity: A primary ethical concern is the potential for GenAI to undermine academic integrity. Chatterjee and Bhattacharjee (2020) applied the Technology Acceptance Model (TAM) to study educators' and students' perceptions of AI in education, revealing concerns about accuracy, biases, and over-reliance on AI-generated content. Similarly, McKnight and Shipp (2024) question the ethical implications of using GenAI as a writing tool, suggesting that it may undermine the development of authentic writing skills.

2) Bias and Fairness: GenAI models are trained on vast datasets that may contain inherent biases, leading to the generation of content that reflects these prejudices. Bozkurt (2023) explores this phenomenon, noting that the continuous need to adapt to new technologies can affect teachers' psychological well-being. This is particularly relevant in the context of English language education, where the pressure to integrate GenAI tools effectively can be overwhelming.

3) Data Privacy and Security: The use of GenAI often involves processing personal data, raising concerns about privacy and data security. Lee and Maeng (2023) investigate high school students' perceptions of AI chatbots in English learning, identifying benefits such as increased engagement and personalized feedback, but also concerns about the accuracy and appropriateness of AI-generated responses. These findings suggest that while GenAI has the potential to enhance English communication skills, its effectiveness is contingent upon careful implementation and ongoing evaluation.

4. Dependency and Skill Development: There is a risk that reliance on GenAI tools may impede the development of critical language skills. McKnight and Shipp (2024) argue that viewing GenAI merely as a tool can lead to a superficial understanding of its impact on writing, potentially diminishing students' ability to develop authentic writing skills.

5) Ethical Use and Regulation: The rapid advancement of GenAI technologies has led to technostress among educators. Bozkurt (2023) explores this phenomenon, noting that the continuous need to adapt to new technologies can affect teachers' psychological well-being. This is particularly relevant in the context of English language education, where the pressure to integrate GenAI tools effectively can be overwhelming.

While GenAI presents promising opportunities for ELT, it is imperative to address the associated ethical considerations. Ensuring academic integrity, mitigating biases, safeguarding data privacy, preventing over-reliance, and establishing clear ethical guidelines are essential steps toward responsible integration of GenAI in language education.

DATA AND METHODOLOGY

The databases used for this review included Scopus, Web of Science, ERIC, and Google Scholar. These databases were selected for their comprehensive coverage of educational research. Key search terms included “Generative AI in language learning,” “AI and English communication,” “GenAI tools in education,” and “AI in teaching listening, speaking, reading, and writing.” These terms were chosen to encompass a broad range of studies related to the application of AI in enhancing English communication skills.

RESULTS AND DISCUSSION

In the field of English language teaching, Generative Artificial Intelligence (GenAI) tools have emerged as key technologies that help enhance the four essential communication skills: listening, speaking, reading, and writing. Below is a detailed examination of how GenAI tools impact each of these skills, along with examples of AI programs that support language learning in these areas.

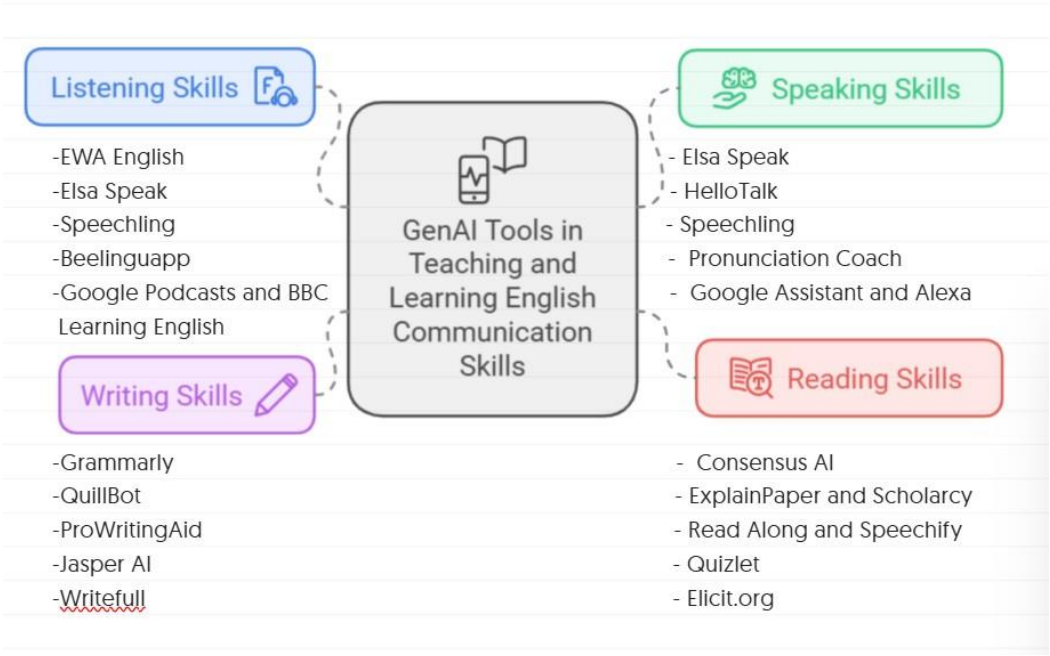


Figure 1 – GenAI Tools in Teaching and Learning English Communication Skills

1. Listening Skills

GenAI tools are revolutionizing the way listening skills are taught and practiced. AI-driven programs can provide learners with access to a variety of audio content at different levels of complexity, which can be tailored to individual needs. These tools often incorporate real-time feedback, helping learners improve their listening comprehension.

1) EWA English: EWA combines AI-driven lessons with real-world English content, including audio clips from movies and shows, making listening practice more relevant and enjoyable. Students can listen to authentic dialogues and complete exercises that build comprehension. EWA also includes quizzes and spaced repetition to reinforce learning. (Ask a Tech Teacher, 2024)

2) Elsa Speak: Primarily focused on pronunciation, Elsa Speak uses AI to analyze and improve English speech. It provides feedback on pronunciation accuracy, which is essential for both listening and speaking skills, helping students discern subtle sounds and accents. This feedback loop improves listening comprehension by training the ear to recognize correct sounds. (Academia Insider, 2024).

3) Speechling: This AI-based tool combines listening and speaking exercises to build comprehension. Speechling uses native-speaker audio clips, which students listen to and then mimic, receiving immediate feedback. It is especially useful for improving the ability to understand different accents and speeds of speech in English. (High Point University Library, 2024)

4) Beelinguapp: Beelinguapp offers bilingual reading and listening practice by displaying stories and articles side by side in two languages. It allows students to follow along with the text while listening to native speaker audio, supporting contextual understanding and vocabulary growth. This tool is particularly helpful for students who need visual support while improving their listening skills. (Academia Insider, 2024).

5) Google Podcasts and BBC Learning English: These apps provide a variety of English-language podcasts covering a range of topics. BBC Learning English, for example, includes structured programs specifically for English learners, complete with transcripts. This setup helps students listen and follow along, allowing for progressive improvement in both comprehension and vocabulary. (High Point University Library, 2024)

2. Speaking Skills

Speaking is one of the most challenging skills to practice, but GenAI tools have made significant strides in providing learners with environments where they can practice speaking English without the fear of judgment. Here are some AI tools designed to boost English-speaking proficiency:

1) Elsa Speak: This AI-driven pronunciation app helps students refine their accent by providing instant feedback on pronunciation accuracy. It uses speech recognition to detect errors and offers guidance to improve fluency, making it especially useful for non-native speakers who want to sound more natural. (Academia Insider, 2024).

2) HelloTalk: HelloTalk connects users with native speakers globally, allowing them to practice speaking through text, voice, and video chats. The app uses AI to suggest corrections, improving language accuracy and conversational fluency while providing a cultural exchange opportunity. (High Point University Library, 2024)

3) Speechling: Speechling combines listening and speaking practice, using native-speaker audio for students to mimic and compare. Students record their speech and receive detailed feedback from professional coaches, enhancing pronunciation, intonation, and pacing skills. (Academia Insider, 2024).

4) Pronunciation Coach: This tool provides a phonetic breakdown of words and helps students practice difficult sounds by displaying visual aids of mouth movements. The AI evaluates pronunciation and fluency, helping students tackle challenging sounds and improve clarity. (Ask a Tech Teacher, 2024)

5) Google Assistant and Alexa: Conversational AI tools like Google Assistant and Alexa are useful for daily speaking practice. Students can ask questions, engage in conversations, or practice commands, which can enhance their spontaneous speaking abilities and build confidence. (High Point University Library, 2024)

3. Reading Skills

AI tools are becoming increasingly valuable for improving English reading skills among undergraduate students. Here are several AI-based tools and strategies tailored for enhancing comprehension, vocabulary, and engagement with English texts:

1) Consensus AI for Academic Reading: Consensus AI is an academic search engine that helps students quickly access and understand research literature by summarizing and highlighting key findings. It’s particularly helpful for students needing to develop reading comprehension in technical fields, as it provides accessible summaries of dense, scholarly content, helping students grasp complex ideas and expand their academic vocabulary. (Ask a Tech Teacher, 2024)

2) ExplainPaper and Scholarcy: Tools like ExplainPaper and Scholarcy break down research articles into manageable, summarized sections, allowing students to focus on the main points without becoming overwhelmed by jargon and lengthy paragraphs. This targeted summarization can help students build confidence with complex texts, which is crucial for improving reading fluency and comprehension. (Academia Insider, 2024).

3) Text-to-Speech and Language Learning Platforms (like Read Along and Speechify): Text-to-Speech tools, such as Read Along by Google or Speechify, allow students to listen to texts while reading. This dual approach can aid in pronunciation and comprehension, especially for non-native speakers. Listening while reading along enhances word recognition and helps students become familiar with sentence structure and flow, which is essential for advanced English reading skills. (Ask a Tech Teacher, 2024)

4) Interactive Vocabulary Builders (e.g., Quizlet): For undergraduates who need to expand their academic vocabulary, AI-powered vocabulary tools like Quizlet and Vocabulary.com provide context-rich flashcards, quizzes, and games. These tools use spaced repetition and other AI techniques to ensure students retain vocabulary over time, aiding reading comprehension across various disciplines. (High Point University Library, 2024)

5) AI-Powered Question Generators (such as Elicit.org): Question generators encourage critical engagement with texts by asking students questions based on the content they're reading. Tools like Elicit use AI to create comprehension questions, prompting students to think critically about the material and reinforcing reading comprehension through active engagement. (Academia Insider, 2024).

4. Writing Skills

AI tools are highly effective in helping undergraduate students improve their English writing skills, especially in academic and formal contexts. Here are several AI tools and strategies that can assist students in enhancing grammar, coherence, vocabulary, and overall writing quality:

1) Grammarly: Grammarly is a popular AI-powered writing assistant that provides grammar, punctuation, and style suggestions in real-time. It also offers tone detection, which helps students adjust their writing to match the intended audience or setting. Additionally, Grammarly Premium provides in-depth explanations for corrections, allowing students to learn and avoid repetitive mistakes. (Grammarly, 2024)

2) QuillBot: QuillBot is an AI-powered paraphrasing tool that helps students rephrase sentences and expand vocabulary. It can assist in avoiding plagiarism by allowing students to express ideas in their own words, which is crucial for academic integrity. QuillBot also includes features like summarizing and grammar checking, making it an all-in-one tool for refining written content. (Academia Insider, 2024).

3) ProWritingAid: ProWritingAid combines grammar checking, style suggestions, and structure analysis. It helps students improve coherence and organization by providing insights into sentence structure and flow. ProWritingAid's detailed reports and interactive suggestions are particularly helpful for students working on lengthy essays or research papers. (High Point University Library, 2024)

4) Jasper AI (Formerly Jarvis): Jasper AI is a content generator that offers guided templates for academic essays, blogs, and formal writing. It helps students develop initial ideas, and outlines, or even generate sentence structures that can serve as a starting point. Though not a replacement for original work, Jasper provides a structured approach that is beneficial for students learning to organize their thoughts coherently. (Ask a Tech Teacher, 2024)

5) Writefull: Designed for academic writing, Writefull provides language feedback based on academic corpora, making it ideal for students writing research papers. It suggests academic vocabulary and offers specific sentence templates commonly used in academic texts, which is beneficial for undergraduates working to improve the formality and professionalism of their writing. (Academia Insider, 2024).

CONCLUSION

The integration of Generative Artificial Intelligence (GenAI) tools in teaching English communication skills demonstrates substantial potential across key areas: listening, speaking, reading, and writing. GenAI tools offer personalized and adaptive learning experiences that foster engagement and accessibility in language acquisition. For listening and speaking, GenAI-powered applications like speech recognition and conversational AI provide interactive practice, real-time feedback, and exposure to various accents and contexts, promoting fluency and pronunciation accuracy. In reading, AI-driven summarization and vocabulary tools aid comprehension, enabling students to navigate complex texts with confidence. For writing, grammar-checking, paraphrasing, and style- enhancement tools empower students to improve language accuracy and coherence, essential for both academic and professional communication.

GenAI's effectiveness in English language learning lies in its ability to individualize instruction and promote autonomous learning. These tools cater to diverse learning preferences, making English language acquisition more inclusive and tailored to individual needs. However, responsible implementation is crucial; educators must guide students to ensure ethical use and balance AI assistance with traditional learning methods. Future research should further explore the nuanced impacts of GenAI in language education, considering cultural contexts, learning outcomes, and student engagement. Overall, GenAI presents a transformative opportunity in language education, significantly contributing to developing comprehensive English communication skills for diverse learners.

REFERENCES

Ask a Tech Teacher. (2024). 4 innovative ways to enhance reading comprehension with AI tools. *Ask a Tech Teacher*. Retrieved from https://askatechteacher.com

Academia Insider. (2024). The best AI tools for research papers and academic research. *Academia Insider*. Retrieved from https://academiainsider.com

Bozkurt, A. (2023). Generative AI-powered conversational educational agents: The inevitable paradigm shift. *Asian Journal of Distance Education,* 18(1), 198-204. Retrieved from https://eric.ed.gov/?id=EJ1389644

Bradley Irwin. (2024). Exploring generative AI tools for English language learning: Student adoption and perceptions. *Sophia University Junior College Division Faculty Journal,* 45, 127-137.

Chatterjee, S., & Bhattacharjee, K. (2020). Technology acceptance model and the Unified Theory of Acceptance and Use of Technology in studying users' acceptance of artificial intelligence in education. *Education and Information Technologies*, 25(3), 2851-2867. https://doi.org/10.1007/s10639-020-10153-6

Chen, M.-R. A. (2024). Metacognitive mastery: Transformative learning in EFL through a generative AI chatbot fueled by metalinguistic guidance. *Educational Technology & Society*, 27(3), 407-427. Retrieved from https://eric.ed.gov/?id=EJ1437573

High Point University Library. (2024). AI tools for academic research. *High Point University*. Retrieved from https://highpoint.edu

Fruzsina Szabó, & Szoke, J. (2024). How does generative AI promote autonomy and inclusivity in language teaching? *ELT Journal*. https://doi.org/10.1093/elt/ccae052

Grammarly. (2024). Grammarly: Free online writing assistant. *Grammarly*. Retrieved from https://www.grammarly.com

Lee, J., & Maeng, S. (2023). High school students' perceptions of AI chatbots in English learning: Engagement and accuracy. *Journal of Language and Education Technology*, 28(3), 401-415.

McKnight, K., & Shipp, D. (2024). Ethical implications of AI in writing skills development. *English Language Teaching Journal*, 32(1), 123-134.

Pack, C., & Maloney, D. (2023). Exploring generative AI in language learning materials and assessment creation. *Journal of Educational Technology & Society*, 26(2), 175-190.

Van den Berg, G. (2024). Generative AI and educators: Partnering in using open digital content for transforming education. *Open Praxis*, 16(2), 130-141. Retrieved from https://eric.ed.gov/?id=EJ1427528

Szabó, F., & Szoke, J. (2024). Exploring the integration of generative AI in English language teaching: A tool for engagement and digital literacy. *Journal of Language Learning Technology*, 32(3), 205-220.

TRANSFORMING SME ENTREPRENEURS IN THE DIGITAL AGE BASED ON THE CONCEPT OF LIFELONG LEARNING THROUGH ONLINE PLATFORMS AND ARTIFICIAL INTELLIGENCE

Pornprasit Denmoree[A], Sukhoom Phannarong[B], Pimonpun Boonyasana[C], Pirapong Prabripu[D]

ABSTRACT

This research aimed to analyze the factors affecting the selection of appropriate learning methods of learners by studying a sample group of 181 people from 5 industrial groups: manufacturing, trade, services, community enterprises, and others. The tools used to collect data include interview forms, questionnaires and tests. The learning methods studied consisted of 3 formats: participating in online training via Zoom, participating in online training via platform/website, and watching online teaching clips. Data analysis used descriptive statistics and multiple logistic regression analysis. The results show that education level and learning style preference are important factors in choosing learning style. Undergraduate and higher education learner prefer watching past teaching clips rather than attending live online training. And those who prefer blended learning mode are more likely to choose on-site online training. In addition, the results of the course satisfaction assessment found that learners were highly satisfied, with an average score of 93.06 out of a full 100 points. The results of this study have important implications for the development and improvement of future online teaching models, highlighting the importance of designing flexible and diverse courses to meet the needs of learners with different educational levels and learning styles. To meet the needs of learners with different levels of education and learning styles, as well as taking into account the diversity of learners from various industries. The application of this research will improve the efficiency of online teaching and promote learning in the digital age.

Keywords: *Transformation, Entrepreneurs, Lifelong learning, Online platforms, Artificial intelligence*

[A] *Center of Research and Development of Community Economy, Faculty of Economics, Chiang Mai University, Thailand. Email: pornprasit_tsh@hotmail.com Orcid: https://www.econ.cmu.ac.th/*

[B] *Center of Research and Development of Community Economy, Faculty of Economics, Chiang Mai University, Thailand. Email: sukhoomphun@gmail.com Orcid: https://www.econ.cmu.ac.th/*

[C] *Center of Research and Development of Community Economy, Faculty of Economics, Chiang Mai University, Thailand. Email: pui.econ@gmail.com Orcid: https://www.econ.cmu.ac.th/*

[D] *Faculty of Economics, Chiang Mai University, Thailand. Email: pirapong.p@cmu.ac.th Orcid: https://www.econ.cmu.ac.th/*

INTRODUCTION

In Thailand today, the role of being an entrepreneur is more relevant to everyone, not only business administration students, but also various faculties such as medicine, engineering, pharmacy, education, etc. who want to have their own business, including those who have permanent jobs in companies or organizations, are more interested in becoming entrepreneurs. Some people want to have their own business, some do not have enough knowledge, but have capital to start their own business, but in the end the business fails because they do not truly understand how to operate a business, which is a result of the lack of opportunity to access knowledge. Although the university has a program to support business incubators in higher education institutions (University Business Incubator/UBI), there are limitations in terms of the number of students that can be accepted and the qualifications of the students. External agencies have organized short- term training courses for entrepreneurs, which have limitations in terms of learning time and place, lacking in-depth specific knowledge content and integration of knowledge across disciplines necessary for running a real business.

Therefore, it can be seen that the university does not have courses open to students and those interested in becoming entrepreneurs. In addition, most of the previous research related to Thai entrepreneurs has studied the characteristics of entrepreneurs, lacking research on finding teaching methods for developing entrepreneurs at all levels. For example, new entrepreneurs, professional entrepreneurs, and interdisciplinary knowledge required for integrating actual business operations are in line with the entrepreneurial status report of Thailand's Global Entrepreneurship Society Research Program. Bosma&Kelley (2018) found that the most unfavorable environmental factors for entrepreneurship in Thailand include a lack of entrepreneurial education opportunities in the institutions they studied. And consistent with the report of the Committee on the Promotion of Economic Reform, the National Reform Council, on the creation of an entrepreneurial society (The Secretariat of The House of Representatives, 2016, p.3-5), which mentioned that the infrastructure and supportive measures of the government sector are not conducive to the creation of entrepreneurs, including the lack of promotion of learning to become entrepreneurs after graduation. In addition, Thai entrepreneurs who are in the learning/experimental phase often do not have sufficient basic knowledge in doing business. Therefore, they may have to try and fail and fail in starting their businesses many times. Meanwhile, the quality of knowledge provision and development of business management skills of Thais (Quality and Management School) still has a lot of room for development.

Using technology to create educational innovation, with the development potential as the goal, broaden our horizons and let learners really understand, as the breakthrough point of innovation, because knowledge will produce the greatest benefits when applied, bringing the greatest benefits to individuals and society. Educational innovation that changes the existing learning style is technology-based learning, such as online teaching. The connection point is that communication technology is the medium of learning, and it is the education that every student can get, with the choice of learning, so as to study at a convenient time. Innovative education makes closed education an open system, such as MOOC system, which is provided by many universities.

From the above problems, the researcher has taken the “Entrepreneurship Curriculum Using Online Learning”, which is part of the doctoral thesis or Phase 1: New Entrepreneur (Start-up Entrepreneur 5.0), to further develop into the Entrepreneurship Curriculum 5.0 Phase 3: Application in Real Work Module 1: Operation Management 1. The researcher has conducted an experiment under the project “Entrepreneurship Development 5.0 (Entrepreneur 5.0)”, Center of Research and Development of Community Economy, Faculty

of Economics, Chiang Mai university, to develop and promote Micro SME / Community Enterprise / SME entrepreneurs to grow and be able to compete with other regions on a sustainable international level. To reduce the gap and increase learning opportunities for everyone who is interested, there is an opportunity to learn specialized subjects and knowledge, can develop various skills to understand and have the ability to do business, and prepare the ability to enter the real world of competition.

LITERATURE REVIEW

Entrepreneurship education

Entrepreneurship education is a process of preparing students or graduates who are interested in becoming entrepreneurs to have entrepreneurial skills or to enhance the necessary characteristics that can be applied in practice in running a new business or company. (Denmoree P.,2021)

The ADDIE model for e-learning

The Food and Agriculture Organization of the United Nations (2011) has developed a model for online learning or e-learning called “The ADDIE model for e-learning” consisting of 5 steps: analysis, design, development, implementation and evaluation.

AI technology in education

In education, the use of AI technology will be able to reduce the burden on teachers in managing lessons, content and checking various exercises. The results can be used to adjust the content to help children with learning problems understand the lessons better. In addition, AI technology can be used to create lessons that are appropriate for each student (Personalized Learning), including the use of AI technology as a tutor to adjust online learning content to suit the abilities of the students. (Kamphiranon, S.,2021)

The researcher applied the ADDIE model concept in the development process of the 5.0 curriculum Phase 3: Application in real work, Module 1: Operation management 1, using online platform teaching and teaching method 2: AI teaching clips. The ADDIE model has a 5-step curriculum research and development process: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation. The curriculum consists of 4 subjects: 1) Purchasing Management, 2) Production Planning Management, 3) Warehouse Management, and 4) Transportation Management.

DATA AND METHODOLOGY

The sample

The sample group consisted of 181 people from 5 groups: 1) manufacturing industry 2) trading industry 3) service industry 4) community enterprise and 5) others

Research tool

interview forms, questionnaires and tests (4 subjects).

Validity/reliability

Interview forms, questionnaires: The results of the IOC evaluation from 5 experts examined content validity, construct validity. Language accuracy. Take the results from the consideration of experts to calculate the IOC index (Index of item-objective congruence), with each item. Value is 0.5 or more. The suggestions were revised and improved and the researcher took the questionnaire and tested it (Try out) with a group of 30 entrepreneurs by testing to find the confidence value. (Reliability) of this questionnaire uses Cronbach's alpha coefficient formula. The reliability of the questionnaire has an alpha coefficient.

Tests (4 subjects): to check the quality of the instruments, the researcher gave the 4 subjects and the entrepreneurship curriculum to experts to evaluate in a quality assessment form, which is a 5-point Likert scale: 5 (most), 4 (much), 3 (moderate), 2 (less), and 1 (least). In terms of content, the assessment will be about the subject content, the presentation, the use of language, the correctness, the clarity of the test of each lesson, etc. Then, the assessment results of the experts of each of the 5 subjects and the entrepreneurship curriculum were averaged and compared with the quality criteria. This will show the level of quality of the lessons of the 4 subjects and the developed entrepreneurship curriculum. The quality in each aspect must be at a higher level before it can be implemented

Data collection

The researcher specifically contacted university lecturers/The Federation of Thai Industriesand others, to request cooperation in publicizing the entrepreneurship course using online teaching to interested students/people who voluntarily participated in the trial study through a website that the researcher developed and created. Interested students/people can apply to study via email/Line/website. After that, the researcher will notify the list of those eligible to study. The period for publicizing and accepting applications is 1 month.

Research Methodology

This research is a step in the experimental phase of entrepreneurship courses through online platforms. The research procedures are as follows:

1) The researcher took the entrepreneurship course that had been evaluated by experts and tested it with a sample group of 180 people. The selection criteria were those who were interested in the knowledge and skills and willingly participated in the trial and registered through the website www.entrepreneuronline-learning.com that the researcher created.

2) The researcher conducted a pilot study of the entrepreneurship course using online teaching with a sample group of 180 people, comparing before and after learning of the sample group, and finding satisfaction with the entrepreneurship course.

3) Research period: March 2023 to March 2024

RESULTS AND DISCUSSION

There are a total of 180 samples, including the following dependent variable and independent variables (Table 1). The dependent variable on which this study is the type of suitable teaching method (Suitable Learning Method: SLM), which is divided into 3 forms as follows: Participating in online training via Zoom (SLM1) accounted for 30 percent, participating in online training via platform/website (SLM2) accounted for 21.67 percent, and

watching online teaching clips via platform/website (SLM3) accounted for the highest proportion at 48.33 percent.

In terms of independent variables, including demographic factors and factors related to learning, it was found that the majority of the sample was female, accounting for 69.44 percent. In terms of job positions, it was found that most were at the assistant manager, manager, and supervisor levels, accounting for 39.44 percent, followed by senior executives and officers/ staff/employees, with an equal proportion of 27.78 percent. In terms of educational level, it was found that the majority of the sample group had a bachelor's degree, accounting for 63.89 percent, followed by a post-bachelor's degree, accounting for 26.67 percent. The achievement of teaching methods which considering the scores that the learners achieved, it was found that most were at a moderate level, accounting for 58.33 percent. In terms of preferred learning formats, it was found that the majority of the sample group preferred the hybrid learning format B, which is a combination of AI-based lecture clips and self-learning lessons on a platform/website, accounting for 43.33 percent, followed by hybrid learning format A (15 percent) and hybrid learning format C (14.44 percent), respectively. For the course satisfaction score, it was found that the average was 93.06 points, with a standard deviation of 7.35 points, reflecting a fairly high level of satisfaction among course participants.

Table 1 – General characteristics of variables used in the study (N=180)

Variables	Freq.	Percent
Dependent variable	54	30
SLM (Suitable Learning Method)	39	21.67
Participate in online training via Zoom (SLM1)	87	48.33
Participate in online training via the platform/website www.entrepreneuronline-learning.com (SLM2)		
Watch past teaching clips online via the platform/website www.entrepreneuronline-learning.com (SLM3)		
Independent variables		
GEN (Gender)		
Male (0)	55	30.56
Female (1)	125	69.44
POS (Position)		
Executives, Senior Executives, Business Owners, Entrepreneurs (POS1)	50	27.78
Assistant Manager Manager Supervisor (POS2)	71	39.44
Officer/ Staff/ Employee (POS3)	50	27.78
Teacher, Freelance, Others (POS4)	9	5.00
EDU (Education Level)		
Below bachelor's degree (EDU1)	17	9.44
Bachelor's degree (EDU2)	115	63.89
Higher than bachelor's degree (EDU3)	48	26.67
ACH2 (Achievement Method 2)		
Low level (ACH21)	45	25.00
Moderate level (ACH22)	105	58.33
High level (ACH23)	30	16.67
PLS (Preferred Learning Style)		
Type 1: 4-subject lecture clips (using AI) (PLS1)	5	2.78
Type 2: 4 subject lecture clips (via Zoom) (PLS2)	7	3.89
Type 3: Learn lessons on the platform/website www.entrepreneuronline-learning.com by yourself (PLS3)	6	3.33
Type 4: Mixed Type A is Type 1: 4 subject lecture clips (using AI) + Type 2: 4 subject lecture clips (via Zoom) (PLS4)	27	15.00
Type 5: Mixed Type B is Type 1: 4-subject lecture clips (using AI) + Type 3: Learn lessons on the platform/website www.entrepreneuronline-learning.com by yourself (PLS5)	78	43.33

Variables	Freq.	Percent
Type 6: Mixed C is Type 2: 4 lecture clips (via Zoom) + Type 3: Learn lessons on the platform/website www.entrepreneuronline-learning.com by yourself (PLS6)	26	14.44
Type 7: Mixed Type D is Type 1: 4 lecture clips (using AI) + Type 2: 4 lecture clips (via Zoom) + Type 3: Learn lessons on the platform/website www.entrepreneuronline-learning.com by yourself (PLS7)	31	17.22
SAT (Satisfaction Score)		
Mean = 93.0646 Std. dev. = 7.3490		

Source: Based on analysis.

Results of multinomial logistic regression analysis to study the factors affecting the selection of appropriate learning methods using learning method type 3 (SLM3: Watch past teaching clips online via the platform/website online) as the reference group. Table 2 shows the coefficients and relative risk ratios (RRR), while Table 3 shows the average marginal effects (AME) of each factor.

The analysis results showed that the level of education had a significant effect on the choice of learning methods. From Table 2, it was found that those with bachelor's and higher bachelor's degrees were less likely to choose learning method 1 (SLM1: participating in online training via Zoom) than those with lower than bachelor's degree (β = -1.3755 and -1.7257, respectively, $p < 0.05$), with RRR values of 0.2527 and 0.1780, respectively. This is consistent with Table 3, which shows that having a bachelor's and higher bachelor's degrees decreased the chance of selecting SLM1 by 27.33% and 30.56%, respectively ($p < 0.05$), while increasing the chance of selecting SLM3 by 20.47% ($p = 0.066$) and 29.84% ($p < 0.05$), respectively.

The preferred learning style had a significant effect on the choice of all three learning methods, namely SLM1. From Table 2, it was found that the blended learning styles A (PLS4) and C (PLS6) were more likely to choose SLM1 than the blended learning style D (β = 1.3803 and 1.7834, respectively, $p < 0.05$), with RRR values of 3.9760 and 5.9499, respectively. Table 3 confirms that the C hybrid increased the chance of selecting SLM1 by 26.20% ($p < 0.05$).

For SLM2, from Table 2, it shows that blended learning models A, B, and C were more likely to choose SLM2 than blended learning model D (β = 2.4150, 2.0540, and 2.1805, respectively, $p < 0.05$), with RRR values of 11.1896, 7.7988, and 8.8506, respectively. Table 3 confirms that the combinations A and B increased the chance of selecting SLM2 by 24.27% and 22.64%, respectively ($p < 0.05$), while SLM3. From Table 3, it is shown that the combinations A, B, and C decreased the chance of selecting SLM3 by 39.05%, 27.45%, and 42.04%, respectively ($p < 0.01$).

Other variables such as gender, position, teaching method performance, and course satisfaction scores did not show any statistically significant relationship with learning method selection.

Considering the appropriateness of the model, the pseudo R2 value of the model is 0.1030, which represents a relatively low explanatory power. However, LR chi2 (30) is equal to 38.73 (p=0.1319), indicating that the model is somewhat appropriate.

Table 2 – Results of multiple logistic regression analysis for factors affecting the selection of appropriate learning methods

Variable	Coefficient	Std. err.	z	P>z	RRR	[95% conf.	Interval]
Outcome 1 vs. 3 (base)							
Sex(Female=1)	0.2675	0.4255	0.630	0.530	1.3067	0.5675	3.0088
POS (Position)							
POS1	-0.1668	0.9381	-0.180	0.859	0.8464	0.1346	5.3224
POS2	-1.0940	0.9842	-1.110	0.266	0.3349	0.0487	2.3049
POS3	-0.8438	1.0194	-0.830	0.408	0.4301	0.0583	3.1713
EDU (Education Level)							
EDU2	-1.3755	0.6553	-2.100	0.036	0.2527	0.0700	0.9128
EDU3	-1.7257	0.7732	-2.230	0.026	0.1780	0.0391	0.8103
ACH (Achievement Method)							
ACH1	0.5299	0.6090	0.870	0.384	1.6988	0.5149	5.6046
ACH2	-0.0729	0.5442	-0.130	0.893	0.9297	0.3200	2.7014
SAT (Satisfaction Score)							
SAT	-0.0050	0.0283	-0.180	0.860	0.9950	0.9414	1.0518
PLS (Preferred Learning Style)							
PLS1	0.0281	1.2736	0.020	0.982	1.0285	0.0848	12.4820
PLS2	0.9176	1.0127	0.910	0.365	2.5034	0.3439	18.2205
PLS3	0.1265	1.0587	0.120	0.905	1.1349	0.1425	9.0390
PLS4	1.3803	0.6848	2.020	0.044	3.9760	1.0388	15.2178
PLS5	0.7198	0.5623	1.280	0.201	2.0540	0.6823	6.1831
PLS6	1.7834	0.6740	2.650	0.008	5.9499	1.5877	22.2973
Outcome 2 vs. 3 (base)							
Sex Female=1)	-0.1425	0.4389	-0.320	0.745	0.8672	0.3668	2.0498
POS (Position)							
POS1	-0.8922	0.9637	-0.930	0.355	0.4097	0.0620	2.7093
POS2	-1.0594	1.0007	-1.060	0.290	0.3467	0.0488	2.4641
POS3	-1.3001	1.0547	-1.230	0.218	0.2725	0.0345	2.1536
EDU (Education Level)							
EDU2	-0.3084	0.8218	-0.380	0.707	0.7346	0.1468	3.6776
EDU3	-0.8445	0.9384	-0.900	0.368	0.4298	0.0683	2.7040
ACH (Achievement Method)							
ACH1	-0.0857	0.6587	-0.130	0.897	0.9179	0.2524	3.3379
ACH2	-0.1842	0.5603	-0.330	0.742	0.8317	0.2774	2.4939
SAT (Satisfaction Score)							
SAT	-0.0222	0.0288	-0.770	0.441	0.9780	0.9243	1.0349
PLS (Preferred Learning Style)							
PLS1	-13.1726	1321.6800	-0.010	0.992	0.0000	0.0000	.
PLS2	1.2516	1.3618	0.920	0.358	3.4958	0.2423	50.4330
PLS3	-13.0807	1147.0280	-0.010	0.991	0.0000	0.0000	.
PLS4	2.4150	0.9096	2.650	0.008	11.1896	1.8816	66.5426
PLS5	2.0540	0.7994	2.570	0.010	7.7988	1.6279	37.3631
PLS6	2.1805	0.9269	2.350	0.019	8.8506	1.4388	54.4435

Remark: N = 180, Log-likelihood = -168.55006, LR chi2(30) = 38.73, Prob > chi2 = 0.1319
Pseudo R2 = 0.1030, AIC = 401.1001, BIC = 503.2747
Source: Based on analysis.

Table 3 – Average Marginal Effects of Different Factors on the Probability of Choosing Each Learning Method

Variable	Outcome 1			Outcome 2			Outcome 3		
	dy/dx	SE	P>|z|	dy/dx	SE	P>|z|	dy/dx	SE	P>|z|
Sex(Female=1)	0.0590	0.0713	0.4080	-0.0402	0.0661	0.5430	-0.0188	0.0772	0.8070
POS (Position)									
POS1	0.0494	0.1745	0.7770	-0.1408	0.1623	0.3860	0.0913	0.1550	0.5560
POS2	-0.1199	0.1781	0.5010	-0.1042	0.1709	0.5420	0.2241	0.1615	0.1650
POS3	-0.0625	0.1859	0.7370	-0.1549	0.1738	0.3730	0.2174	0.1694	0.1990
EDU (Education Level)									
EDU2	-0.2733	0.1255	0.0290	0.0687	0.0970	0.4790	0.2047	0.1113	0.0660
EDU3	-0.3056	0.1408	0.0300	0.0072	0.1101	0.9480	0.2984	0.1308	0.0230
ACH (Achievement Method)									
ACH1	0.1117	0.1080	0.3010	-0.0510	0.0946	0.5900	-0.0607	0.1128	0.5910
ACH2	-0.0015	0.0912	0.9870	-0.0254	0.0857	0.7670	0.0268	0.0992	0.7870
SAT (Satisfaction Score)									
SAT	0.0005	0.0049	0.9200	-0.0031	0.0041	0.4470	0.0026	0.0051	0.6050
PLS (Preferred Learning Style)									
PLS1	0.0182	0.2068	0.9300	-0.0612	0.0421	0.1460	0.0429	0.2090	0.8370
PLS2	0.1351	0.1951	0.4890	0.0848	0.1421	0.5510	-0.2199	0.2010	0.2740
PLS3	0.0347	0.1779	0.8450	-0.0612	0.0421	0.1460	0.0265	0.1805	0.8830
PLS4	0.1478	0.1181	0.2110	0.2427	0.1021	0.0170	-0.3905	0.1225	0.0010
PLS5	0.0482	0.0886	0.5870	0.2264	0.0681	0.0010	-0.2745	0.0982	0.0050
PLS6	0.2620	0.1208	0.0300	0.1583	0.0907	0.0810	-0.4204	0.1195	0.0000

Source: Based on analysis.

CONCLUSION

This study focused on analyzing the factors affecting the selection of appropriate learning methods of learners by using Multinomial Logistic Regression analysis from a sample of 180 people. The analysis results revealed that important factors affecting the selection of learning methods were educational level and preferred learning styles.

Educational level is a significant factor influencing the choice of learning methods, with those with bachelor's and higher degrees more likely to choose the learning method of watching online teaching clips rather than participating in online training via Zoom, compared to those with less than bachelor's degree. This study's results may reflect that those with higher education may require more flexibility in their learning and are better able to self-manage their learning.

Preferred learning format is another factor that significantly influences the choice of learning method. Those who prefer blended learning formats are more likely to choose online training via Zoom or via a platform/website rather than watching a recorded teaching clip. The results of this study suggest that learners who prefer blended learning formats may prefer more interaction and engagement in learning than purely self-directed learning.

Interestingly, other factors such as gender, position, teaching method achievement, and course satisfaction scores did not show a statistically significant relationship with learning method choice, which may indicate that learning method choice depends more on personal factors and learning experiences than on demographic factors or general course satisfaction.

However, it should be noted that this model had a relatively low pseudo R2 value (0.1030), indicating that there may be other factors not included in this study that may have influenced the choice of learning method. Therefore, future research may consider additional

factors such as technological skills, previous online learning experiences, or more specific learning styles.

The results of this study have important implications for the development and improvement of future teaching models, especially in the context of online learning. Educational administrators should consider designing flexible and diverse curricula to meet the needs of learners with different levels of education and learning preferences. In addition, a learning support system that facilitates self-learning for those with higher education should be developed. At the same time, interaction and participation in learning should be promoted for those who prefer a blended learning model. This is consistent with the research of Rajit, W. (2014), who stated that designing online teaching to develop learners is very important for today's IT world because online teaching can respond to the needs of both learners and teachers very well, as well as reducing many limitations of teaching.

REFERENCES

Bosma, N., and, & Kelley, D., (2018). *Global Entrepreneurship Monitor: 2018/2019 Global Report*. https://www.c4e.org.cy/reports/2019/Global_GEM_Report_2018_2019.pdf

Denmoree P. (2021). *Development of Entrepreneurship Curriculum with Online Learning to Promote Entrepreneurship for Students on Higher Education Institutions*, A Dissertation of Doctor of Philosophy in Higher Education, Department of Educational Policy, Management and Leadership, Faculty of Education, Chulalongkorn University.

Food and Agriculture Organization of the United Nations. (2011). *E-learning methodologies: a guide for designing and developing e-learning courses*. Rome, Italy, 21-24.

Kamphiranon, S. (2021) *Artificial Intelligence in Thailand*. https://online.fliphtml5.com/pyepm/wcdo/

Office of the Secretary-General of the House of Representatives (2016). *Report of the Committee on Economic Reform of the National Reform Council on the Creation of an Entrepreneurial Society* (Office of the Secretary-General of the House of Representatives, pp. 3-5. https://library.parliament.go.th/th/national-reform/2559-03-31-economic

Rajit, W. (2014). *Application of e-learning. Master Thesis of Science Program in Information Technology*. Mahanakorn University of Technology. (in Thai)

DEVELOPMENT OF A LIFELONG LEARNING PLATFORM TO PROMOTE DIGITAL CITIZENSHIP SKILLS

Wachira Brahmawong[A]

ABSTRACT

This research aimed to develop a conceptual framework and prototype for a lifelong learning platform to promote digital citizenship skills. The study employed a mixed-methods approach, including document analysis, expert interviews, and prototype development.

First, relevant literature and theories were reviewed to establish the foundational concepts. Then, 15 experts were interviewed to gather insights on platform requirements. Based on these findings, a conceptual framework was drafted and evaluated by 5 experts, yielding a very high overall quality rating (Mean = 4.60, S.D. = 0.55).

The resulting prototype platform encompasses four main components: 1) Front-end systems for user interaction, 2) Back-end systems for data and content management, 3) Infrastructure and technologies to support scalability and security, and 4) Supporting processes for continuous improvement and user engagement.Key features of the platform include personalized learning paths, interactive content formats, gamification elements, community-building tools, and AI-powered content recommendations. The platform aims to cater to diverse user groups, from students to working professionals, promoting continuous skill development in areas such as digital literacy, online safety, and ethical technology use.

This research contributes to the field of educational technology by proposing an innovative approach to fostering digital citizenship skills through a comprehensive, user-centered lifelong learning platform. Future work will focus on implementing the prototype and conducting user trials to further refine the platform's effectiveness in promoting digital citizenship competencies.

Keywords: *Digital Citizenship, Lifelong Learning, E-learning Platform, Educational Technology*

INTRODUCTION

The increasing digitalization of society has transformed how people work, learn, communicate, and engage in civic activities. As digital technologies become more integrated into daily life, the ability to use these tools effectively, responsibly, and ethically has emerged as a fundamental requirement for meaningful participation in modern society. Digital citizenship, which encompasses skills ranging from digital literacy and online safety to ethical technology use and critical thinking, has therefore become an essential competency for individuals of all ages and backgrounds.

[A] *Office of Education Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: Wachira1984@gmail.com*

However, several challenges persist in developing these crucial skills. Traditional educational approaches often fail to address the dynamic nature of digital technologies and the evolving needs of different user groups. Moreover, existing platforms typically offer fragmented learning experiences, focusing on isolated aspects of digital citizenship rather than providing a holistic approach to skill development. Additionally, the rapid pace of technological change requires continuous learning and adaptation, making traditional one-time training programs insufficient for long-term skill development.

Recent studies highlight significant gaps in digital citizenship education, particularly in:

1. Personalization of learning experiences to accommodate different skill levels and learning preferences
2. Integration of practical, real-world applications with theoretical knowledge
3. Continuous assessment and adaptation of learning content to keep pace with technological changes
4. Community engagement and peer learning opportunities
5. Accessibility and inclusivity for diverse user groups

Furthermore, the COVID-19 pandemic has accelerated digital transformation across sectors, making digital citizenship skills more critical than ever. The sudden shift to online learning, remote work, and digital services has exposed disparities in digital competencies and highlighted the urgent need for effective, accessible training solutions.

This research responds to these challenges by proposing an innovative approach to digital citizenship education through a comprehensive lifelong learning platform. The platform aims to address current limitations by:

- Providing personalized learning pathways that adapt to individual needs and progress
- Incorporating interactive and engaging content formats that promote active learning
- Leveraging artificial intelligence for content recommendations and learning optimization
- Building community features that facilitate peer learning and support
- Ensuring accessibility and inclusivity through universal design principles

The significance of this research lies in its potential to:

1. Bridge the digital skills gap across different demographic groups
2. Promote responsible and ethical use of digital technologies
3. Enhance social participation and civic engagement in the digital age
4. Support continuous professional development in an increasingly digital workplace
5. Foster digital resilience and critical thinking skills

To achieve these objectives, this study employs a mixed-methods approach, combining theoretical research with practical application and expert input. The resulting conceptual framework and prototype aim to serve as a foundation for developing more effective digital citizenship education solutions.

LITERATURE REVIEW

The research is grounded in several key concepts and theories, which are detailed as follows:

2.1 Digital Citizenship

Digital citizenship is defined as the skills, knowledge, understanding, attitudes, and behaviors necessary for appropriate and responsible technology use. It encompasses the following key elements:

2.1.1 Components of Digital Citizenship

- Digital Access: The ability to access and use digital technologies
- Digital Literacy: The ability to understand, evaluate, and use digital information
- Digital Communication: Skills for effective communication through digital channels
- Digital Security: Understanding and practices for safety in the digital world
- Digital Ethics: Awareness and adherence to ethical principles in technology use

2.1.2 Importance in the Digital Age

- Participation in digital society
- Career development in the digital era
- Security and privacy protection
- Appropriate digital identity formation

2.2 Lifelong Learning

Lifelong learning is the continuous, voluntary, and self-motivated pursuit of knowledge for personal or professional reasons throughout life. It encompasses the following concepts:

2.2.1 Key Principles of Lifelong Learning

- Continuity of learning
- Self-directed learning
- Adaptation to change
- Essential skills development

2.2.2 Forms of Lifelong Learning

- Formal learning
- Non-formal learning
- Informal learning
- Experiential learning

2.3 E-learning Platforms

E-learning platforms are online systems that facilitate learning through various digital tools and content delivery methods. They comprise:

2.3.1 Platform Components

- Learning Management Systems
- Content Management Systems
- Assessment Tools
- Progress Tracking Systems

2.3.2 Key Features

- Interactivity
- Learning flexibility
- Learner customization
- Collaborative learning support

2.4 Educational Technology

Educational Technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources. It includes:

2.4.1 Principles of Educational Technology

- Instructional design
- Learning media development
- Learning assessment
- Learning system management

2.4.2 Innovations in Educational Technology

- Artificial Intelligence in education
- Blended learning
- Virtual Reality technology
- Learning analytics

The integration of these concepts and theories leads to the development of a conceptual framework for a lifelong learning platform aimed at promoting digital citizenship skills, taking into account the needs of diverse users and rapid technological changes.

2.5 Theoretical Framework Integration

The theoretical framework for this research integrates these key concepts to address:

2.5.1 Platform Design Principles

- User-centered design
- Adaptive learning pathways
- Inclusive access
- Engagement and motivation

2.5.2 Learning Content Development

- Competency-based curriculum
- Interactive content formats

- Real-world applications
- Assessment strategies

2.5.3 Technology Implementation

- System architecture
- User interface design
- Data security and privacy
- Performance optimization

2.6 Conceptual Model Development

The conceptual model developed from this theoretical foundation considers:

2.6.1 Core Components

- Learning delivery mechanisms
- User engagement strategies
- Progress tracking systems
- Community building tools

2.6.2 Supporting Elements

- Technical infrastructure
- Content management
- User support systems
- Quality assurance processes

DATA AND METHODOLOGY

The study employed a mixed-methods approach consisting of three main phases to develop a comprehensive understanding and solution for digital citizenship education. The research design integrated both qualitative and quantitative methods to ensure robust findings and practical outcomes.

3.1 Document Analysis

The first phase involved a systematic review of relevant literature, theories, and existing platforms, encompassing:

3.1.1 Literature Review Process

- Academic databases searched: Scopus, Web of Science, ERIC, and Google Scholar
- Publication timeframe: 2015-2024
- Key search terms: digital citizenship, lifelong learning, e-learning platforms, educational technology
- Document types: peer-reviewed articles, conference proceedings, technical reports, and white papers

3.1.2 Analysis Framework

- Content analysis of selected documents
- Thematic categorization of findings
- Identification of best practices and gaps
- Comparative analysis of existing platforms

3.1.3 Focus Areas

- Digital citizenship frameworks and components
- Lifelong learning platforms and strategies
- Educational technology trends and innovations
- User experience and interface design
- Learning analytics and assessment methods

3.2 Expert Interviews

The second phase involved in-depth interviews with 15 experts selected based on their expertise and experience:

3.2.1 Expert Selection Criteria

- Minimum 5 years of experience in relevant fields
- Diverse backgrounds (academia, industry, policy)
- Expertise distribution:
  - Digital citizenship (5 experts)
  - Educational technology (5 experts)
  - Platform development (5 experts)

3.2.2 Interview Structure

- Semi-structured interview format
- Duration: 60-90 minutes per interview
- Recording and transcription protocols
- Follow-up clarification procedures

3.2.3 Interview Topics

- Platform requirements and features
- User needs and expectations
- Technical considerations
- Implementation challenges
- Success metrics and evaluation methods

3.2.4 Data Analysis

- Thematic coding of interview transcripts
- Pattern identification and categorization
- Cross-validation of findings
- Integration with document analysis results

3.3 Prototype Development

The third phase focused on developing and evaluating the conceptual framework and prototype:

3.3.1 Framework Development

- Synthesis of findings from phases 1 and 2
- Identification of key components and features
- Development of structural relationships
- Integration of theoretical and practical elements

3.3.2 Expert Evaluation Process

- Selection of 5 evaluation experts
  - Criteria for evaluator selection
  - Expertise distribution
  - Independence from initial expert interviews

3.3.3 Evaluation Criteria 5-point Likert scale assessment covering:

1. Comprehensiveness (1 = Not comprehensive to 5 = Highly comprehensive)
2. Usability (1 = Not usable to 5 = Highly usable)
3. Innovation (1 = Not innovative to 5 = Highly innovative)
4. Feasibility (1 = Not feasible to 5 = Highly feasible)
5. Effectiveness (1 = Not effective to 5 = Highly effective)

3.3.4 Evaluation Results

- Overall quality rating: Mean = 4.60, S.D. = 0.55
- Detailed breakdown by criteria:
  - Comprehensiveness: Mean = 4.75, S.D. = 0.43
  - Usability: Mean = 4.55, S.D. = 0.51
  - Innovation: Mean = 4.65, S.D. = 0.48
  - Feasibility: Mean = 4.40, S.D. = 0.60
  - Effectiveness: Mean = 4.70, S.D. = 0.47

3.3.5 Framework Refinement

- Integration of expert feedback
- Modification of components based on evaluation
- Validation of changes
- Final framework documentation

3.4 Data Quality Assurance

To ensure the reliability and validity of the research:

3.4.1 Quality Control Measures

- Triangulation of data sources

- Member checking of interview transcripts
- Peer review of analysis
- Expert validation of findings

3.4.2 Ethical Considerations

- Informed consent procedures
- Data privacy and confidentiality
- Participant anonymity
- Research integrity protocols

3.5 Limitations and Mitigation Strategies

The methodology acknowledged potential limitations and implemented strategies to address them:

3.5.1 Research Limitations

- Time constraints
- Geographic limitations
- Expert availability
- Technical constraints

3.5.2 Mitigation Strategies

- Careful planning and scheduling
- Virtual interview options
- Flexible expert engagement
- Scalable prototype design

RESULTS AND DISCUSSION

4.1 Conceptual Framework Evaluation

The conceptual framework received a very high overall quality rating (Mean = 4.60, S.D. = 0.55). Key aspects rated highly included:

- Clarity and comprehensiveness of objectives
- Content relevance and up-to-dateness
- Promotion of user interaction and engagement
- Appropriateness of learning management approaches

4.2 Prototype Platform Structure

The prototype platform consists of four main components:

4.2.1 Front-end Systems:

- User registration and profile management
- Course and learning content delivery
- Activity and game systems
- Community and social networking features

4.2.2 Back-end Systems:
- Content and course management
- User data analysis and content recommendation
- Assessment and progress tracking
- Reward and incentive management

4.2.3 Infrastructure and Technologies:
- Web servers and databases
- Content Delivery Network (CDN)
- Data analytics and machine learning systems
- Security and encryption protocols

4.2.4 Supporting Processes:
- Platform design and development
- Content creation and management
- User support and service
- Marketing and public relations

4.3 Key Features

- Personalized learning paths based on user interests and skill levels
- Interactive content formats including videos, quizzes, and simulations
- Gamification elements to increase engagement and motivation
- Community-building tools for peer-to-peer learning and support

AI-powered content recommendations and progress tracking

CONCLUSION

This research contributes to the field of educational technology by proposing an innovative, comprehensive platform for promoting digital citizenship skills through lifelong learning. The high expert evaluation scores validate the conceptual framework's potential effectiveness.

Future work will focus on
1. Implementing the full prototype based on the conceptual framework
2. Conducting user trials to gather feedback and assess the platform's effectiveness
3. Refining the platform based on user data and emerging technologies
4. Exploring partnerships with educational institutions and organizations for wider adoption

By addressing the critical need for digital citizenship education in an accessible and engaging format, this platform has the potential to significantly impact individuals' ability to navigate and contribute positively to the digital era.

NEEDS ASSESSMENT OF DIGITAL TECHNOLOGY SKILLS AMONG LOCAL ENTREPRENEURS IN PHETCHABURI PROVINCE: PREPARING FOR THE DEVELOPMENT OF A DIGITAL PLATFORM TO FOSTER INNOVATION AND ENHANCE LOCAL PRODUCT VALUE

Thanathnuth Chatpakkarattana[A], Patthanan Bootchuy[B], Chutiwat Suwatthipong[C]

ABSTRACT

The transition of Thailand's economic structure towards a "Value-Based Economy" under the Thailand 4.0 policy, aimed at achieving stability, prosperity, and sustainability, necessitates shifting from a "produce more, gain less" model to a "produce less, gain more" approach. Community businesses or community enterprises as key mechanisms driving Thailand's economic growth sustainably. However, current challenges include a high degree of product homogeneity leading to intense competition and issues related to the adoption of information technology. To prepare for developing a digital platform that fosters innovation and adds value to local products, it is essential to study the digital technology skill needs of local entrepreneurs in Phetchaburi Province. A qualitative research approach was employed, involving in-depth interviews with four key informants—local entrepreneurs from Ban Lat and Tha Yang districts, representing a total of 60 members.

The findings reveal that: 1) The primary communication device used by entrepreneurs is the smartphone, with LINE and social media platforms such as Facebook Pages being the main channels for product posting. However, these are used at a basic level and do not fully support commercial sales; 2) There is a need to develop skills in live-streaming product sales via online or other social media channels and to gain knowledge in creating digital content to enhance product value; and 3) The development of digital platforms to support innovation should involve user-friendly systems that align with the digital tools familiar to entrepreneurs, alongside accessible knowledge resources for product development.

Keywords: *Digital Platform, Digital Technology Skills, Local Entrepreneur, Value-Based Economy, Community Enterprise*

[A] *Ph.D. in Educational Technology and Communications, Office of Educational Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: thanathnuth.cha@stou.ac.th*

[B] *Ph.D. in Educational Technology and Communications, Office of Educational Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: patthanan.boo@stou.ac.th*

[C] *Ph.D. in Educational Technology and Communications, Office of Educational Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: chutiwat.suw@stou.ac.th*

UTILISING MOBILE GAMIFICATION IN EMERGING DIGITAL LEARNING TECHNOLOGIES FOR SUSTAINABILITY: A CASE STUDY

Ratna Marta Dhewi[A], Rahmat Budiman[B]

ABSTRACT

In an era marked by rapid technological advancement, digital tools hold the potential to create equitable and inclusive learning environments. This study examines the evolving landscape of digital education, focusing on open universities, particularly Universitas Terbuka in Indonesia. By analysing the perceptions of 584 academic staff across three distinct study programmes, this research assesses the acceptance and expectations of emerging learning models. A significant finding reveals the necessity for personalised learning approaches to accommodate diverse learning preferences; notably, 51.7% of participants favour audiovisual formats, while 34.2% prefer kinesthetic or simulation-based methods. Although the majority of participants possess access to laptops (82.4%) and smartphones (74.7%), only 18.69% express interest in adopting advanced technologies like artificial intelligence and virtual reality, largely due to concerns about cost and usability. This raises a critical question: How can the integration of advanced learning technologies be made both effective and accessible? One innovative solution explored is the Universitas Terbuka Virtual Audit Center (UT-VAC), a mobile application designed as a learning simulation tool. The study also evaluates various mobile gamification strategies that have demonstrated positive impacts on student outcomes across different universities. Ultimately, this research provides valuable insights into enhancing distance education through technology, contributing to academic discourse and the practical development of cost-effective, user-friendly learning solutions. It underscores the significance of mobile gamification as a sustainable approach to improving educational access and outcomes in emerging digital learning environments.

Keywords: *Mobile Gamification, Digital Learning Technologies, Sustainability*

[A] *Master degree, Accounting, Universitas Terbuka, Indonesia. Email: rmdhewi@ecampus.ut.ac.id Orcid: https://orcid.org/0000-0003-1827-6905*

[B] *Doctoral degree, English Education, Universitas Terbuka, Indonesia. Email: budiman@ecampus.ut.ac.id Orcid: https://orcid.org/0000-0002-8673-7278*

UNLOCKING INSIGHTS: EXPLORING FILIPINO NURSING UNIVERSITIES' EXPERIENCE WITH THE FILIPINIZED LEARNING MANAGEMENT SYSTEM

Rita C. Ramos[A], Primo Garcia[B], Queenie Roxas-Ridulme[C], Ria Valerie Cabanes[D], Hanna May Rosario[E], Marie Karen Enrile[F], Ronaldo De Jesus[G], Cariza Dolliente, Adrian Sandoval

ABSTRACT

Background and Purpose: *The Filipinized Learning Management System (FLMS) was designed by Filipino researchers, to combat the challenges of internet connectivity and contextual barriers in online learning. In this study, the researchers implemented and focused on the integration of FLMS across three state universities in the Philippines during the second semester of the academic year 2022-2023. The primary objective was to identify specific obstacles encountered by users and leverage these insights to enhance and improve the FLMS.*

Design and Methods: *Faculty and students in the three state universities were asked about their experiences with the system using a convergent mixed methods approach. A series of focus group discussions and the Technology-Acceptance Model questionnaire were utilized and analyzed by NVIVO software and Jamovi, respectively.*

Results and Discussion: *Preliminary findings suggest that the Filipinized LMS showed the potential to mitigate connectivity issues, with a user-friendly interface and offline capabilities. It fostered engagement and community through collaborative tools and discussion boards. However, users also encountered noteworthy technical challenges, prompting recommendations for system optimization. In summation, the implementation of the Filipinized LMS yielded crucial revelations regarding its capacity to alleviate connectivity hurdles and augment online education in the Philippines. Beyond highlighting the advantages of the FLMS, this study yielded essential guidelines for future enhancements, setting the trajectory for improved e-learning experiences within the country.*

[A] *Ph.D. in Educational Research, Evaluation and Measurement, Faculty of Management and Development Studies, University of the Philippines, Los Baños, Laguna, Philippines. Email: rita.ramos@upou.edu.ph Orcid: https://orcid.org/0000-0003-2275-2943*

[B] *Ph.D. in Organizational Studies, Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines.*

[C] *Ph.D. in Education, Faculty of Management and Development Studies, University of the Philippines Open University Los Baños, Laguna, Philippines. Email: queenie.ridulme@upou.edu.ph*

[D] *Ph.D. candidate in Health Education, Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines. Email: riavalerie.cabanes@upou.edu.ph*

[E] *M.A. in Anthropology, FED, University of the Philippines Open University, Los Baños, Laguna, Philippines. Email: hannamay.rosario@upou.edu.ph*

[F] *Project Research Assistant, Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines. Email: kay.enrile@upou.edu.ph*

[G] *Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines. Email: ronaldo.dejesus@upou.edu.ph*

Conclusion and Implications: *Overall, implementing the Filipinized LMS provided insights into its potential to alleviate connectivity challenges and improve online education in the Philippines, with recommendations for future enhancements. The investigation underscores the significance of using the mixed methods approach in understanding a context-sensitive situation in developing learning technologies, particularly in regions with unique challenges. As online education continues to gain prominence globally, endeavors like the Filipinized LMS contribute to the ongoing evolution of education systems, ensuring inclusivity and efficiency for diverse learning communities. The researchers further recommend exploring the effectiveness of the system in other fields of courses.*

Keywords: *convergent mixed methods, online learning, learning management system, user experience*

SMART SELF-CHECK: MASTERING SELF- REGULATION THROUGH DIGITALLY- ASSISTED MONITORING TOOL: A MIXED METHODS STUDY

Rita C. Ramos[A], John Addy Garcia[B]

ABSTRACT

Background and Purpose*: Independent learning is a crucial component of open and distance learning, claims De Silva (2019). Independent learners are self-reliant individuals who take responsibility for their studies (Corno, 2001 as cited by De Silva, 2019). As a result, De Silva (2019) recommends that teachers support self-regulated learning in ODL environments by utilizing the proper techniques and resources. Based on theory, a digital tool integrated into the learning management system (LMS) in this study helps open and distance learners with self-regulation strategies like SRLs and time management.*

Specifically, this study examined how the Digitally-Assisted Monitoring System (DAMS) impacted self-regulated learning and to what extent did the quantitative and qualitative results coincide or differ?

Design and Methods*: An intervention and an outcome were determined causally using a quasi-experimental mixed methods design (pre- and post-test design) triangulation mixed methods design using the convergence model (Harris et al., 2006). During the Master of Science program at a university, four (34) participants took part in the Statistics for Science Education class.*

Results and Discussion*: Pre- and post-assessment surveys, focus groups, interviews, and a thematic analysis were used to assess the impact of the digitally-assisted monitoring tool (DAMS)on self-regulation on academic outcomes. Regulation Learning Questionnaire (RLQ) pre- and post-test results did not differ significantly using Wilcoxon signed rank tests. Qualitative and quantitative outcomes diverged when it came to task understanding, goal setting, monitoring, evaluation, and adaptation.*

Conclusion and Implications*: Based on the results of this study, it can be concluded that the quantitative and qualitative results diverged. According to the quantitative results, no significant differences could be determined between before and after the use of the digitally supported monitoring system with regard to task understanding, goal setting and planning, monitoring and evaluation as well as adaptation and finally adaptation. While the qualitative results suggested that the use of a digitally assisted monitoring system enabled a more differentiated and detailed elaboration of the impact on self-regulated learning.*

Keywords: *Self-regulation, feedback, online learning*

[A] *Ph.D. in Educational Research, Evaluation and Measurement, Faculty of Management and Development Studies, University of the Philippines, Los Baños, Laguna, Philippines. Email: rita.ramos@upou.edu.ph Orcid: https://orcid.org/0000-0003-2275-2943*

[B] *Ph.D. in Educational Psychology, BAGCED, De La Salle University, Los Baños, Manila, Philippines. Email: john.addy.garcia@dlsu.edu.ph*

PIONEERING CARE: LAUNCHING THE PHILIPPINES' FIRST PEDIATRIC ONCOLOGY TELEMEDICINE INITIATIVE

Rita C. Ramos[A], Loyda Amor N. Cajucom[B], Queenie R. Ridulme[C], Myra D. Oruga[D], Primo G. Garcia[E], Raya Kathreen T. Fuentes, Raymund Kernell B. Mañago, Maria Joanna G. Viñas

ABSTRACT

Also, the Telemedicine component was included in the web-based platform that was designed to help patients, caregivers, and healthcare providers gain access to palliative care information, services, and experts so that pediatric cancer patients and their families would have a better quality of life. The researchers can determine areas for improvement by monitoring and evaluating the outcomes of its use, which will assist in the continuous development of the platform. In this study, the quality of palliative care provided to pediatric cancer patients was evaluated for its impact on their quality of life. For patients, caregivers, and health professionals, this information was useful in identifying gaps in knowledge and practice to help plan, develop, and improve education and health programs related to palliative care. Furthermore, it emphasizes the effectiveness of web-based platforms as well as a means of delivering healthcare in low-resource settings. Using this data, healthcare professionals can develop other web-based health campaigns. When the web-based pediatric palliative care service provider is well-established in the country, its framework can be applied to other diseases and other health services as well.

Keywords: *Telemedicine, Pediatric Oncology Pioneering Care*

[A] *Ph.D. in Educational Research, Evaluation and Measurement, Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines. Email: rita.ramos@upou.edu.ph Orcid: https://orcid.org/0000-0003-2275-2943*

[B] *BSN, RN, MA, New Era University, Manila, Philippines.*

[C] *Ph.D. in Education, Faculty of Management and Development Studies, University of the Philippines Open University Los Baños, Laguna, Philippines. Email: queenie.ridulme@upou.edu.ph*

[D] *Ph.D. in Human Nutrition, Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines. Email: myra.oruga@upou.edu.ph Orcid: https://orcid.org/0000-0002-4022-7475*

[E] *Ph.D. in Organizational Studies, Faculty of Management and Development Studies, University of the Philippines Open University, Los Baños, Laguna, Philippines.*

TRANSFORMING ASSESSMENT IN HIGHER EDUCATION: CROSS-BORDER PERSPECTIVES FROM ROMANIA AND REPUBLIC OF MOLDOVA

Gabriela Grosseck[A], Roza Dumbrăveanu[B], Laura Malița[C]

ABSTRACT

Introduction/Objective: *This study explores the impact of generative AI (gAI) on assessment practices in higher education, with a focus on Romania and the Republic of Moldova. The objective is to assess how these countries have integrated gAI into their assessment frameworks and to identify the challenges they face in doing so.*

Methods: *A bibliometric analysis using Biblioshiny on Web of Science publications evaluated gAI adoption in higher education assessment practices in Romania and Moldova. The study examined document types, productivity trends, key sources, contributing institutions, and collaboration patterns, alongside digital infrastructure, institutional support, and pedagogical strategies in both countries. It also identified main research themes, recent developments, and critical research gaps.*

Results*: The findings indicate that Romania is better positioned for the rapid adoption of AI-driven assessment tools, benefiting from advanced digital infrastructure and stronger institutional backing. In contrast, Moldova faces infrastructural challenges, which hinder its progress in incorporating AI into assessment practices. Despite these differences, both countries share common concerns, such as the ethical use of AI, the reliability of AI assessments, and addressing the digital divide.*

Conclusion*: The study provides valuable insights for educators and policymakers in both Romania and Moldova on the potential and challenges of integrating gAI into higher education assessment. These findings contribute to the broader discussion on the role of AI in enhancing the accuracy, effectiveness, and equity of student evaluations globally.*

Keywords: *digital assessment, generative artificial intelligence, higher education, Romania, Moldova*

[A] *Assoc. Prof., Department of Psychology, West University of Timisoara, Romania.*
Email: gabriela.grosseck@e-uvt.ro Orcid: https://orcid.org/0000-0001-8933-1022
[B] *Assoc. Prof., "Ion Creangă" Pedagogical State University, Chisinau, Moldova.*
Email: dumbraveanu.roza@upsc.md Orcid: https://orcid.org/0000-0003-2232-3620
[C] *Senior lecturer, Department of Communication Sciences, West University of Timisoara, Romania.*
Email: laura.malita@e-uvt.ro Orcid: https://orcid.org/0000-0002-1927-1375

ENHANCING DIGITAL ACCESSIBILITY AND QUALITY IN OPEN DISTANCE LEARNING: SEAMOLEC'S INITIATIVES AND REGIONAL INSIGHTS

Arie Susanty[A], Wahyudi[B]

ABSTRACT

In today's digital era, access to digital content and services is essential for participation in education, employment, healthcare, and social interactions. However, despite the potential of technology to enhance educational access, digital divides persist, exacerbating educational inequalities, particularly for underprivileged and remote communities. Discussions on the use of educational technology often focus more on technological challenges rather than underlying issues within the education sector. Identifying and addressing these core challenges is crucial. The Global Education Monitoring (GEM) Report 2023 highlights three primary challenges in education: equity and inclusion, quality, and efficiency. This paper explores strategies proposed by SEAMOLEC to improve digital accessibility, ensure inclusiveness, and enhance the quality of Open Distance Learning (ODL). By leveraging offline educational content and digital resources, students in areas with limited internet connectivity can access quality educational materials. Training teachers in the effective use of digital platforms, interactive tools, and resources can facilitate engaging, flexible, and personalized learning experiences. The rapid development of emerging technologies, including immersive technologies and Artificial Intelligence (AI), offers significant opportunities to revolutionize education by creating interactive environments and supporting personalized learning. Enhancing ODL quality involves establishing quality criteria, ensuring consistent implementation, and maintaining high standards across programs. SEAMOLEC's proposed quality framework for ODL encompasses the learning process, technology infrastructure and accessibility, human resources, and evaluation processes. Additionally, reviewing Southeast Asian profiles on educational technology and ODL can provide valuable insights into regional best practices, challenges, and innovations, promoting a collaborative approach to quality improvement. Educational institutions must create robust and dynamic ODL environments that cater to diverse learner needs and foster lifelong learning.

Keywords: *Digital Accessibility, Educational Technology, Open Distance Learning (ODL), Equity and Inclusion, Lifelong Learning*

[A] *SEAMOLEC, Jakarta, Indonesia. Email: susanty@seamolec.org*
[B] *SEAMOLEC, Jakarta, Indonesia.*

ANTENNA OPTIMIZATION FOR SUSTAINABLE IOT ENVIRONMENT

Nithizethe Mhuadthongon[A], Khajitpan Makaratat Kritpolviman[B], Muhammad Ehsan Rana[C], Vazeerudeen Abdul Hameed[D], Sathish Kumar Selva Perumal[E], Kamalanathan Shanmugam[F]

ABSTRACT

In this research, linear array antenna is designed and optimized for sustainable IoT environment. To approach suitable antenna characteristics for sustainable IoT environment such as simplicity, energy efficiency, directivity, and flexibility, the Modified Fruit Fly Optimization Algorithm (MFOA) applied for designing linear array antennain free space is proposed and studied in this research paper. The research methodology presents the versatility of the presented method and the antenna optimization for these criteria. The defined optimization goal of antenna design is to suppress the radiation pattern at specified minimum achievable side lobe level by controlling amplitude parameters of the array antenna. The result of the MFOA is validated by comparing with results obtained from the FOA, and GA methods. The optimized results successfully achieve the desired array factors and minimum side lobe level. The MFOA method consistently outperforms FOA and GA methods in terms of success rate, while also exhibiting significantly reduced computational time compared to the other methods.

Keywords: *Antenna Optimization, Sustainable IoT, MFOA, Side Lobe Level, Array Antenna*

INTRODUCTION

In a modern wireless communication system, it is desirable for the antenna to be highly directive in a particular direction, narrow beamwidth, maximum gain and low side lobe level to achieve the demand of the long distance communication. An array antenna is one typical antenna that can fulfill these requirements. To accomplish these requirements, the antenna elements and geometrical configurations must be appropriately controlled. Specifically, linear array antenna can indeed be suitable for implementing in IoT environments from a sustainability perspective.

[A] *PhD, School of Science and Technology, Sukhothai Thammathirat Open University, Thailand. Email: nithizethe.mhu@stou.ac.th*
[B] *PhD, School of Science and Technology, Sukhothai Thammathirat Open University, Thailand. Email: khajitpan.mak@stou.ac.th (Corresponding Author)*
[C] *PhD, School of Computing, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: muhd_ehsanrana@apu.edu.my*
[D] *PhD, School of Computing, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: vazeer@apu.edu.my*
[E] *PhD, School of Computing, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: sathish@apu.edu.my*
[F] *PhD, School of Computing, Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia. Email: kamalanathan@apu.edu.my*

To design antennas for sustainable IoT devices, several key factors should be considered as stated by Lin, W., and Ziolkowski, R. W. (2020). Low-power antennas should be designed with optimization of antenna gain and directivity to reduce transmission power requirements. In addition, design for supporting sleep modes and adaptive beamforming when IoT devices are inactive and antennas are not in use can minimize energy consumption. This also includes energy harvesting function that enhances energy efficiency. Since IoT devices are installed and deployed as wireless sensor network and many devices are located in remote area, durable materials are considered for compact IoT antenna construction. This causes long-lasting IoT devices and electronic waste reduction. Furthermore, sustainable IoT antenna should be able to adjust functionalities based on environmental conditions, for examples multi-frequency bands operation, power consumption and performance optimization, easy repairment, upgrade, and partial replacements regarding modular designs.

LITERATURE REVIEW

Due to the simplicity in physical construction and implementation, linear array antenna is considered in this research as sustainable IoT antennas (Lin & Ziolkowski, 2020, p.944). Linear array antenna can provide directional gain and reduce transmission power in specific directions. The flexibility of this array pattern allows for optimizing the array elements for specific IoT applications, especially for applications where directional properties align with the use case.

Previous research studies have been conducted and concerned with the synthesis of antenna array. It consists of a wide range of study from analytical methods to global optimization methods. Examples of analytical methods applied to synthesis problems are binominal distribution, Tschebyscheff polynomial, Legendre polynomial etc. (Lin & Ziolkowski, 2021, p.587). However, the synthesis problems have large search space, complexity, and discontinuous behavior, in which they cannot be solved with the analytical methods effectively. Therefore, global optimization methods are good options to solve these problems. Among them, genetic algorithm (GA), particle swarm optimization (PSO), ant colony optimization (ACO), and bee algorithm (BA) have been effectively used in array synthesis for different requirements (Rajo-Iglesias & Quevedo-Teruel, 2007, Guney & Onay, 2010). However, the common disadvantages of these algorithms are complicated computational process and difficulty of comprehension for the beginner.

Another recently invented evolutionary, high-performance algorithm, and suitable for solving the optimization problems is the fruit fly optimization algorithm (FOA) introduced in Pan (2012). FOA is a heuristic searching algorithm inspired by the knowledge of the natural foraging behavior of fruit flies. The algorithm has gained much attention and it is successfully applied in many fields in recent years, for example, financial distress model solving, multidimensional knapsack problem solving, and neural network, among others (Wang, Zheng, & Wang, 2013, Dai, Zhao, Lu, & Dai, 2014, p.160). Nevertheless, similar to other swarm intelligence based algorithms, FOA also has its own disadvantages. According to an empirical study in Iscan and Gunduz (2015), the FOA fails to provide reliable results because it does not have enough searching space, and it is a nonlinear generation mechanism of candidate solution while searching for the global optimum solution of complex problems.

Various approaches have been proposed to overcome the deficiencies of this problem. In Pan, Sang, and Duan (2014), an IFFO algorithm was introduced to improve the effectiveness of the FOA which included an escape parameter that enabled it to run away from the local solution to find out the global optimum solution. To address this issue, Yuan, Dai, Zhao, and

He (2014) adopted a multi-swarm strategy using a revised evaluation function and shrinking the search radius. This method allows the search to be performed uniformly in the domain, therefore the fruit fly swarm enhance its ability to search for a global optimum solution. In Shan, Cao, and Dong (2013), a linear generation mechanism of candidate solution (LGMS) was proposed to replace the nonlinear generation mechanism. It is found that the LGMS method is effective in searching and solving the negative optimum solution in the domain.

The latter optimization algorithms have been proved to be optimally applicable to their respective designs. however, one of the common modifications of these algorithms is that the parameters of distance and smell concentration judgment value of the traditional FOA are eliminated. Furthermore, the fitness function is directly estimated by the continuous variables. This modification is quite suitable for improving the premature convergence ability of the traditional FOA. However, it should be emphasized that the uniqueness of FOA, which is different from other swarm algorithms, is the smell concentration based fitness function. Without this, it may lose its original meaning carried by its name.

In addition, the modified fruit fly optimization algorithm (MFOA) using random search of swarm and self- adaptive population size process for the efficient estimation of a large antenna array design was proposed (Mhudtongon, Phongcharoenpanich, & Kawdungta, 2015). In the optimization process, fruit fly swarm is separated in to two groups: search and discovery groups. This procedure leads to a wider search space. Moreover, the randomness of the foraging behavior of fruit fly swarm in olfactory stage is described by a self-adaptive population size. By using these strategies, the MFOA's ability to avoid local solution is significantly improved.

The objectives of this research are 1) to design and optimize linear array antenna for sustainable IoT environment, and 2) to evaluate the performance of the MFOA method used in this research. The MFOA method is deployed to synthesis problem of the linear array antenna with minimized side lobe level by controlling amplitude parameters of the array antenna. The result of the MFOA method is validated by comparing with results obtained using the traditional FOA, and GA method. Comparisons with several other optimization algorithms prove that the MFOA method yields the superior performance in terms of convergence and accuracy of the results.

Problem Formulation

This section describes the important parameters that impact the radiation pattern and performance of antenna arrays. Problem formulation of the array factor and the side lobe level enable control over the direction, beamwidth, and gain of the main lobe. Optimizing these parameters can achieve desired antenna characteristics.

Array Factor Consideration

It is assumed that there is a linear array of *2n* isotropic elements. The elements are aligned with the z-axis. When the number of the elements is even, the normalized array factor (*AF*) can be represented as (Balanis, 2016)

$$AF_{2N}(\theta) = \sum_{n=1}^{N} I_n cos\left[(2n-1)\frac{\pi d_n}{\lambda} cos\theta\right] \quad (1)$$

An array factor of the odd number of the elements can be expressed as

$$AF_{2N+1}(\theta) = \sum_{n=1}^{N+1} I_n cos\left[2(n-1)\frac{\pi d_n}{\lambda} cos\theta\right] \quad (2)$$

Where I_n is the amplitude current excitation coefficient, $2N$, $2N+1$ is the number of even and odd elements, respectively, d_n is the spacing between each elements, λ is the wavelength of the operating frequency, and θ is the angle between the field direction to the z-axis.

Side Lobe Level

In the problems of the antenna design, there are many important antenna characteristics which could be used to determine the fitness function such as maximum directivity, high gain, minimum side lobe level, depending on the application. For the problem in this paper, the focus is on the application of the MFOA method for optimizing the amplitude of elements of the broadside linear array antenna (i.e., $q_{\max} = 90^{\circ}$ and $\beta = 0$) minimum side lobe level. To achieve this goal, the fitness function, denoted by *f*, is merely chosen to be the side lobe level (abbreviated SLL hereafter) which is computed in the side lobe region as (Recioui, 2012)

$$f = SLL_{dB} = \min\left[\frac{\max(20\log|AF(\theta)|)}{|AF(\theta_{max}=90^{\circ})|}\right] \quad (3)$$

Basic Concept of the MFOA Method

The Fruit Fly Optimization algorithm was developed by Pan (2012). The name of fruit fly optimization refers to algorithm based on the behavior of fruit flies in their searching for food. The food finding process of fruit fly is as follow: firstly, it smells the food source by using osphresis organ, and flies toward that location; secondly, after it gets closed to the food location, the sensitive vision is also used to find food and other fruit flies' flocking location, and then it flies towards that direction. From the FOA procedure, it can be found that there is the limitation in some applications because it cannot estimate the global solution of searching parameters. Therefore, the FOA is modified to have more searching space and global search for discontinuous function.

In Mhudtongon et al. (2015), the modified fruit fly optimization algorithm (abbreviated MFOA) with random search of two groups of swarm and adaptive fruit fly swarm population size was proposed. By using these processes, the optimization performance in terms of global exploration and local exploitation are well balanced. So, the results of the method have better global convergence ability and convergence precision than other searching algorithms. The procedures of the MFOA method for an optimization problem solving can be divided into three parts, namely 1) the initialization of parameter and population location, 2) osphresis-based search, and 3) vision-based search as following. Additionally, A pseudo-code of the MFOA method in detail is described in Figure 1.

1) The initialization of parameters and population location
   Initiate the number of iterations (K).
   Initiate the adaptive population size (NP)
   Randomly generate initial location of fruit fly parameter: *X*_axis and *Y*_axis.
2) Osphresis-based search
   Generate direction and distance for all population (NP) for the first iteration for $i = 1$ to $i = \text{NP}$.
   For group 1,

$$X_i = \text{rand} * (\text{UB-LB}) + \text{LB}, \quad (4)$$
$$Y_i = \text{rand} * (\text{UB-LB}) + \text{LB}. \quad (5)$$

For group 2,

$$X_i = X_axis + rand * (UB-LB) + LB, \quad (6)$$
$$Y_i = Y_axis + rand * (UB-LB) + LB. \quad (7)$$

where rand is a random function which returns a value from the uniform distribution on the interval [0 1], the UB and LB are the upper and lower ranges of fruit fly swarm location in two dimensional searching space, respectively. Then, for each individual fly, estimate the distance ($Dist_i$) and calculate the smell concentration (S_i). The value of S_i is the reciprocal of the distance of the food location to the origin.

$$Dist_i = \sqrt{X_i^2 + Y_i^2} \quad (8)$$

$$S_i = \frac{\text{sign}(e)}{Dist_i} \quad (9)$$

Finally, calculate the smell concentration ($Smell_i$) of the individual fruit fly location by substituting smell concentration judgment value (S_i) into the smell concentration judgment function (or fitness function).

$$Smell_i = \text{Fitness}(S_i) \quad (10)$$

3) Vision-based search

In the vision search stage, the MFOA carries out a greedy selection procedure. First, the individual with the maximum smell concentration among the fruit fly swarm is found:

$$[\text{bestSmell, bestIndex}] = \max(\text{Smell}) \quad (11)$$

Then, the current maximum smell concentration value (bestSmell) is compared with history values (smellBest). If the new bestSmell is better than the old one, the bestSmell will be updated. In this way the fly swarm flies towards the location with the maximum smell concentration value by using vision.

$$\text{smellBest} = \text{bestSmell} \quad (12)$$
$$X_axis = X(\text{bestIndex}) \quad (13)$$
$$Y_axis = Y(\text{bestIndex}) \quad (14)$$

The osphresis-based search stage and the vision-based search stage are repeated, until optimum solution is approached by considering the bestSmell or the last number of iterations. This section has presented only a brief summary of the general concepts that constitute MFOA-based algorithms as well as the details of particular realization. Further information about this can be found in Mhudtongon et al. (2015).

MFOA ANTENNA DESIGN PROCEDURE

In this section, the MFOA optimization design procedure is discussed for broadside linear array antenna in free space. Using the advantages of the MFOA, it is employed to provide good estimates of the amplitude parameters of antenna array. For this purpose, minimum side lobe level is expressed as objective in the target. Figure 1 shows the flowchart of the MFOA antenna design procedure. The design procedure starts with the initial array parameters, and

computes the amplitude parameters on each element by the MFOA. The target of antenna design (minimum side lobe level) is estimated in the next step. In the last process of the antenna design procedure, the algorithm ends if the last number of iterations is arrived or else, enter iterative optimization to repeat the implementation of the step 2 for analyzing the parameter of array antenna to achieve a desired goal. In the next section, numerical results are presented to demonstrate the accuracy and efficiency of the MFOA antenna design procedure.

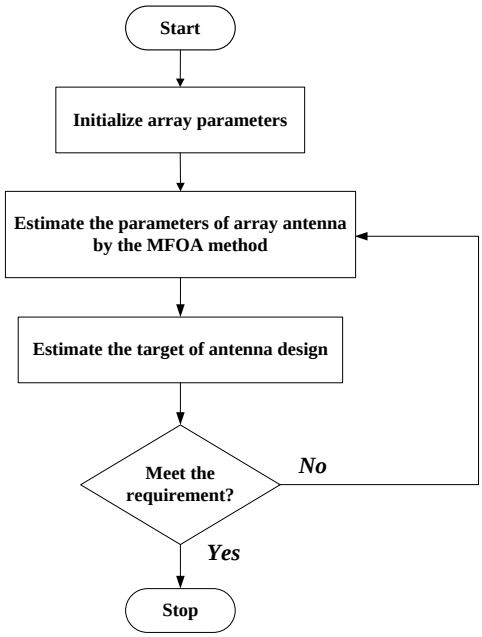


Figure 1 – Flow Chart of the MFOA Antenna Design Procedure

ANTENNA DESIGN AND OPTIMIZATION FOR SUSTAINABLE IOT ENVIRONMENT

To know more about the design procedure, the method described in the previous section is implemented to study the behavior of the minimized side lobe level for nonuniform amplitude linear array antenna with 16 antenna elements (N = 16). In this study, the array pattern, convergence rate and other importance antenna characteristics from the MFOA method is compared with the design of FOA and GA respectively. The results are explained in the subsections.

1) Parameter setting:
   For three different methods in this paper, the population size and maximum number of iterations are equal to 30 and 500 respectively. To show the performance of these methods in terms of accuracy, the simple statistic parameters which can be derived from the results of an algorithm solving a specific numerical problem many times under different initial conditions such as the average best function value and the standard deviation of 50 independent runs.
2) 16 Elements linear array antenna
   When considering a 16 elements half-wavelength-spaced linear array, the excitation amplitude distribution is symmetric with respect to the center of the array. Because of

symmetry, only 8 amplitudes are to be optimized. For design specifications, the excitation currents amplitudes are assumed to be within the range [0 1], and the desired side lobe level should be lower than -25dB.

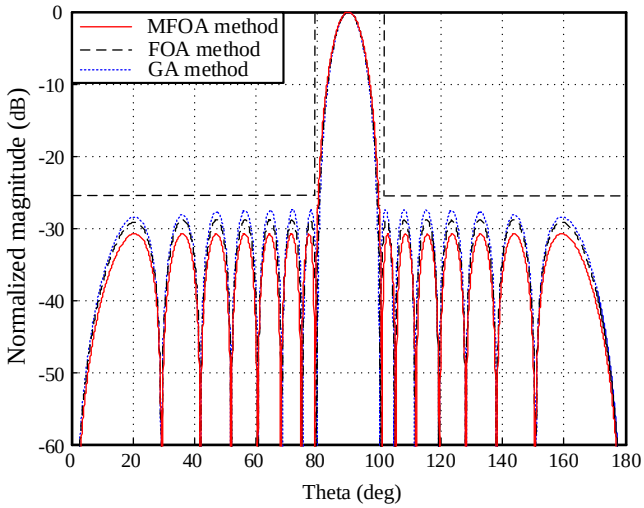


Figure 2 – Normalized Radiation Pattern of 16-Element Broadside Linear array antenna Using the Three Different Methods

From the normalized radiation pattern comparison in Figure 2, it is evident that the beamwidth of these three methods are similar. However, the side lobe level of MFOA is lower than the other methods, the FOA method and the GA method respectively. When compared with the design specifications, the result obtained by the proposed method has been reduced by 5 dB, whereas in the FOA and GA method the results had been reduced by 3 dB and 2 dB, respectively.

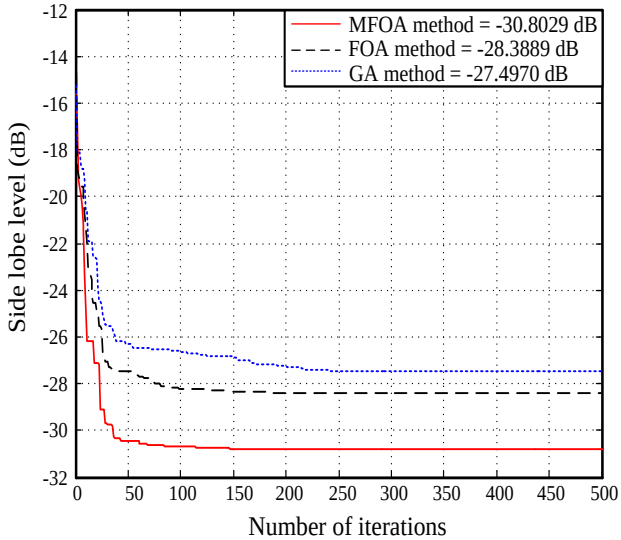


Figure 3 – The Convergence of the Best Fitness Function of the MFOA, FOA, and GA Methods of the Broadside Linear array antenna with 16 Elements

The convergence rate of the fitness value of the MFOA versus the number of iterations for linear array antenna is shown in Figure 3. In this figure, it is clearly seen that the MFOA can perform well in search for the best global solution, that is, the low side lobe level while

other methods met the local solution. The optimum characteristics of the antenna design are given in Table 1. It can be seen from Table 1 that the results of MFOA are better than those of FOA, and GA in terms of accuracy and execution time.

Table 1 – The Optimum Amplitude and the Best Value of Characteristics of the Broadside Linear array antenna with 16 Elements Using Three Different Methods

Parameters	MFOA	FOA	GA
I_1	0.9690	0.8907	0.7939
I_2	0.9216	0.8500	0.7605
I_3	0.8328	0.7751	0.6951
I_4	0.7125	0.6689	0.6060
I_5	0.5738	0.5498	0.5028
I_6	0.4304	0.4194	0.3866
I_7	0.2956	0.3001	0.2900
I_8	0.2600	0.2900	0.2900
HPBW (deg)	8.06	7.84	7.70
SLL (dB)	-30.8029	-28.3889	-27.4970
Mean	-30.7612	-28.3416	-27.3432
Std	0.0911	0.1313	0.1562
Time (s)	334.2822	386.3110	427.4589

The previous results have proved that the approach chosen is successful in terms of side lobe level compressing improvement for the broadside antenna array case. In the experiments for three different methods in this paper, the population size and maximum number of iteration are equal to 10 and 1,000, respectively. To show the performance of the methods in terms of convergence and accuracy, the average best function value, the standard deviation (STD), and the criterion of success (PS) of 100 independent are used, so that the result obtained are reliable.

CONCLUSION

In this paper, antenna optimization using the modified fruit fly optimization algorithm (MFOA) for sustainable IoT environment was presented. The MFOA method was used to synthesized the pattern of broadside linear array antenna with the prescribed side lobe level and to suit with sustainable characteristics of IoT antenna. Minimized side lobe level was achieved by controlling the amplitude of the array elements. The implementation antenna design procedure was described in detail, and 16-element-linear array antenna was discussed to demonstrate its validity. The optimized results showed that the desired array factors, a minimum side lobe level, were successfully obtained. To improve the global search ability and convergence speed of the method, the results of antenna characteristic of the MFOA were compared with the FOA and GA methods. From the analysis, results demonstrated that the MFOA obtained significantly better solution than the other two methods. Finally, the MFOA method was a good candidate for optimizing various electromagnetic problems as it was easy to implement and stably converged to the optimum solution.

REFERENCES

Balanis, C. A. (2016). *Antenna Theory Analysis and Design (4th Edition).* John Wiley and Son, New York, NY, USA.

Dai, H., Zhao, G., Lu, J., and Dai, S. (2014). Comment and improvement on a new fruit fly optimization algorithm: taking the financial distress model as an example. *Knowledge-Based Systems, 59,* 159-160.

Guney, K., and Onay, M. (2010). Bees algorithm for interference suppression of linear antenna arrays by controlling the phase-only and both the amplitude and phase. *Expert Systems with Applications, 37,* 3129-3135.

Iscan, H., and Gunduz, M. (2015), *A Survey on Fruit Fly Optimization Algorithm.* Proceeding of 11th International Conference on Signal-Image Technology & Internet-Based Systems, SITIS, Bangkok, Thailand. (pp.520-527). doi:10.1109/SITIS.2015.55.

Lin, W., and Ziolkowski, R. W. (2020), *Electrically Small Huygens Dipole Array for 5G Wireless Power Transfer Enabled IoT Applications.*, Proceeding of *2020 International Symposium on Antennas and Propagation (ISAP)*, Osaka., Japan. (pp. 587-588). doi: 10.23919/ISAP47053.2021.9391183.

Lin, W., and Ziolkowski, R. W. (2021), *Ultra-Thin Uniform Linear Array of Electrically Small Huygens Dipole Antennas.*, Proceeding of 2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI), Singapore. (pp. 944-945). doi: 10.1109/APS/URSI47566.2021.9703932.

Mhudtongon, N., Phongcharoenpanich, C. and Kawdungta, S. (2015). Modified fruit fly optimization algorithm for analysis of large antenna array. *International Journal of Antennas and Propagation*, 1-11.

Pan, Q.-K., Sang, H.-Y., and Duan, J.-H. (2014), An improved fruit fly optimization algorithm for continuous function optimization problems. *Knowledge-Based Systems, 62*, 69-83.

Pan, W.-T. (2012). A new fruit fly optimization algorithm: taking the financial distress model as an example. *Knowledge-Based Systems*, *26*, 69-74.

Rajo-Iglesias, E., and Quevedo-Teruel, O. (2007). Linear array synthesis using an ant-colony optimization-based algorithm., *IEEE Antennas and Propagation Magazine*, *49*(2), 70-79.

Recioui, A. (2012). Sidelobe level reduction in linear array pattern synthesis using particle swarm optimization. *Journal of Optimization Theory and Applications*, *153*(2), 497-512.

Shan, D., Cao, G. H., and Dong, H. (2013). LGMS-FOA an improved fruit fly optimization algorithm for solving optimization problems. *Mathematical Problems in Engineering*. https://doi.org/10.1155/2013/108768.

Wang, L., Zheng, X.-L., and Wang, S.-Y. (2013) A novel binary fruit fly optimization algorithm for solving the multidimensional knapsack problem. *Knowledge-Based Systems, 48*, 17-23.

Yuan, X., Dai, X., Zhao, J., and He, Q. (2014). On a novel multi-swarm fruit fly optimization algorithm and its application. *Applied Mathematics and Computation*, *233*, 260-271.

DEVELOPMENT OF RIVER/DRAIN SMART TRASH COLLECTOR SYSTEM

Ten Pin Zer[A], Rosli Yusop[B], Dhakshyani Ratnadurai[C], Lau Chee Yong[D], Sathish Kumar Selva Perumal[E], and Poom Juasiripukdee[F]

ABSTRACT

Marine pollution from land-based activities has emerged as a significant issue in our technologically advanced age. To address the issue, this paper presents the development of a smart trash collector system capable of removing pollutants from water, particularly river and drain. A prototype of the system, which consists of conveyor mechanisms to extract and transport floating waste, is constructed. YOLOv8-based machine vision is implemented to perform the identification of recyclable plastic waste, which will be sorted into a separate bin through a diverter. To remove chemical waste, oil skimmer mechanism is used, which extract the waste from the water surface by a rotating acrylic disc. Multiple sensors were also implemented into the system to form a feedback-based system, where conveyors are activated based on signals from ultrasonic sensors, while infrared sensors and load cell are used to estimate the capacity of solid waste bin and chemical waste bin, respectively. An online dashboard is then created using Streamlit, allowing the user to remotely monitor the bin capacity.

Keywords: *floating waste; plastic pollution; trash collector system; smart; YOLO; plastic detection*

INTRODUCTION

Marine pollution has become a significant issue that impacts the sustainability of Earth. Undeniably, the increasing of water-related activities has greatly improved our quality of life. However, these actions have increased the risk of pollutants reaching the water bodies. This directly caused a rise in sources of water pollution when trash and chemical waste are disposed of into the water (Cheng et al., 2022). As a result, the pollutants affect the quality of water, which harms aquatic life and exposes humans and animals to waterborne diseases, affecting the well-being of nature (Kabir & Kabir, 2021).

[A] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: tenpinzer@gmail.com*
[B] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: rosli.yusop@apu.edu.my*
[C] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: dhakshyani@apu.edu.my*
[D] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: laucheeyong@apu.edu.my Orcid: https://orcid.org/0000-0001-7174-4953*
[E] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: sathish@apu.edu.my*
[F] *Ph.D., School of Science and Technology, Sukhothaithammathirat Open University, Thailand. Email: poom.jua@stou.ac.th Orcid: https://orcid.org/0000-0001-9050-0065*

Besides, the rapid increase in plastic resin production and market size also play a vital role in water pollution. With maximizing profits being the primary goal of all manufacturers, it has led to the implementation of plastics in production, replacing materials such as wood and glass due to their superior material characteristics (Singh, Rai, Singh, & Mishra, 2022). This causes a widespread of plastic use in our daily lives, which directly leads to an increase in plastic waste as most plastic products are designed for immediate disposal. When these plastics waste are improperly managed and recycled, a significant amount of plastic waste will be thrown into drains and rivers, eventually entering the ocean, resulting in water pollution (HUANG & LAU, 2020).

LITERATURE REVIEW

In order to conserve the nature, this project focuses on an effective approach to mitigating water pollution, which is to develop a river/drain smart trash collector system (RDSTCS) that is able to remove pollutants from water (YAKUBU, 2017). This approach is considered effective as there still exists small communities in different parts of the world, such as the Dominican Republic, which does not have the luxury of having rubbish bins that will be emptied by waste collection vehicles, leaving the residence to have no other options other than dumping their trash and waste into the river (Thea, Lau, & Lai, 2022). A literature review had been conducted to zanalyze existing systems for removing pollutants from water bodies (Babbar & Yong, 2023). They involves the use of a static system to perform waste collecting, where the main mechanism consists of water pumps or conveyor belts. While involves the use of a dynamic system, which utilizes a motorized system to remove pollutants from water. For this RDSTCS, a static approach is selected to minimize the power consumption of the system by utilizing water current to drive floating waste towards the system (Sing, Vasudavan, & Jabbar, 2023).

As for this system design, it is proposed to remove floating trash and chemical waste, including oil, fuel and detergent, from drains and rivers. The machine design can also extract chemical waste such as oil and detergent from the water surface (Sadhukhan, 2020). However, to further enhance the system, machine vision is used to identify the types of trash collected, where recyclable items such as plastic bottles are sorted into a separate bin(BABBAR & LAU, 2020). Furthermore, sensors are also implemented along with IoT that can send data to a dashboard in order to perform analysis of data obtained by sensors, improving the function of the system in various way (Pierson, 1992).

METHODOLOGY

Figure 1 and Figure 2 above shows the 3D design of the RDSTCS using SOLIDWORKS.

A. 3D Design

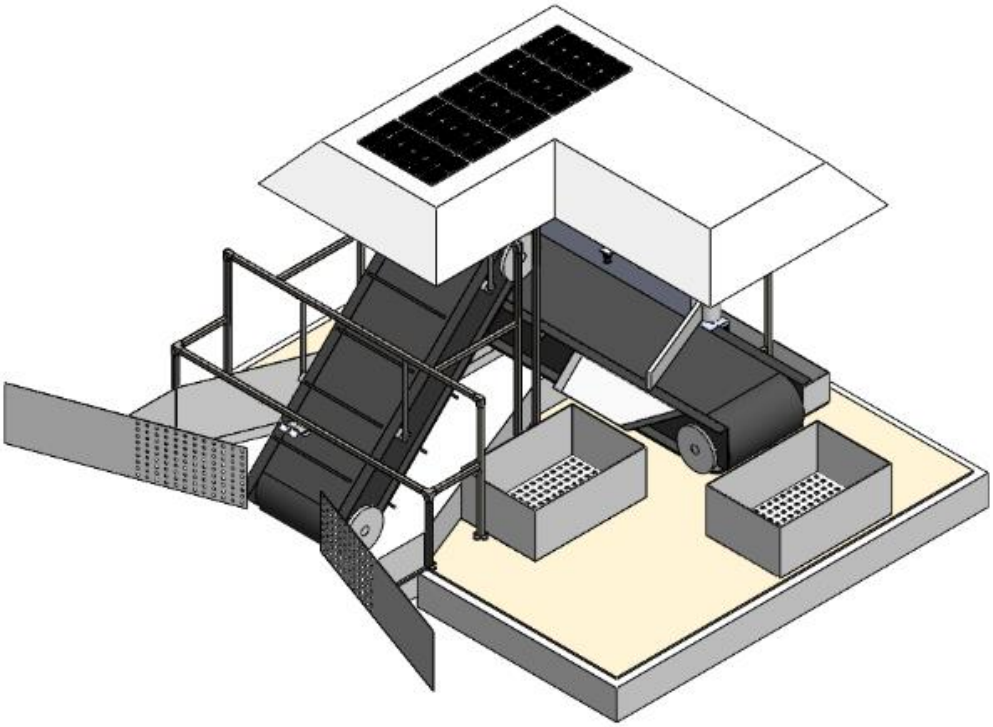


Figure 1 – Isometric view of RDSTCS

.

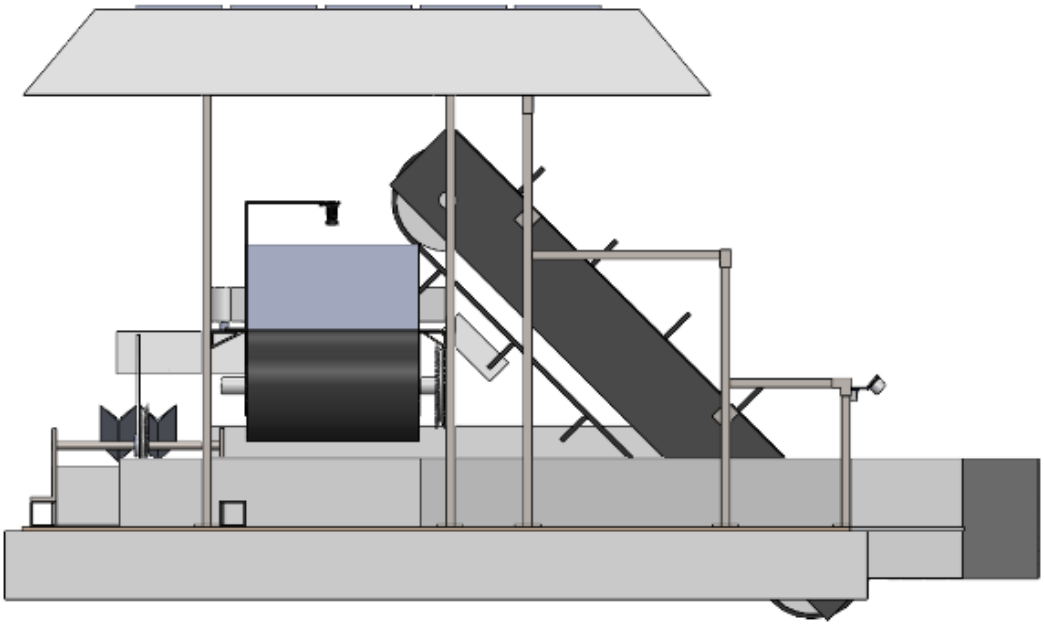


Figure 2 – Side view of RDSTCS

B. Flowchart

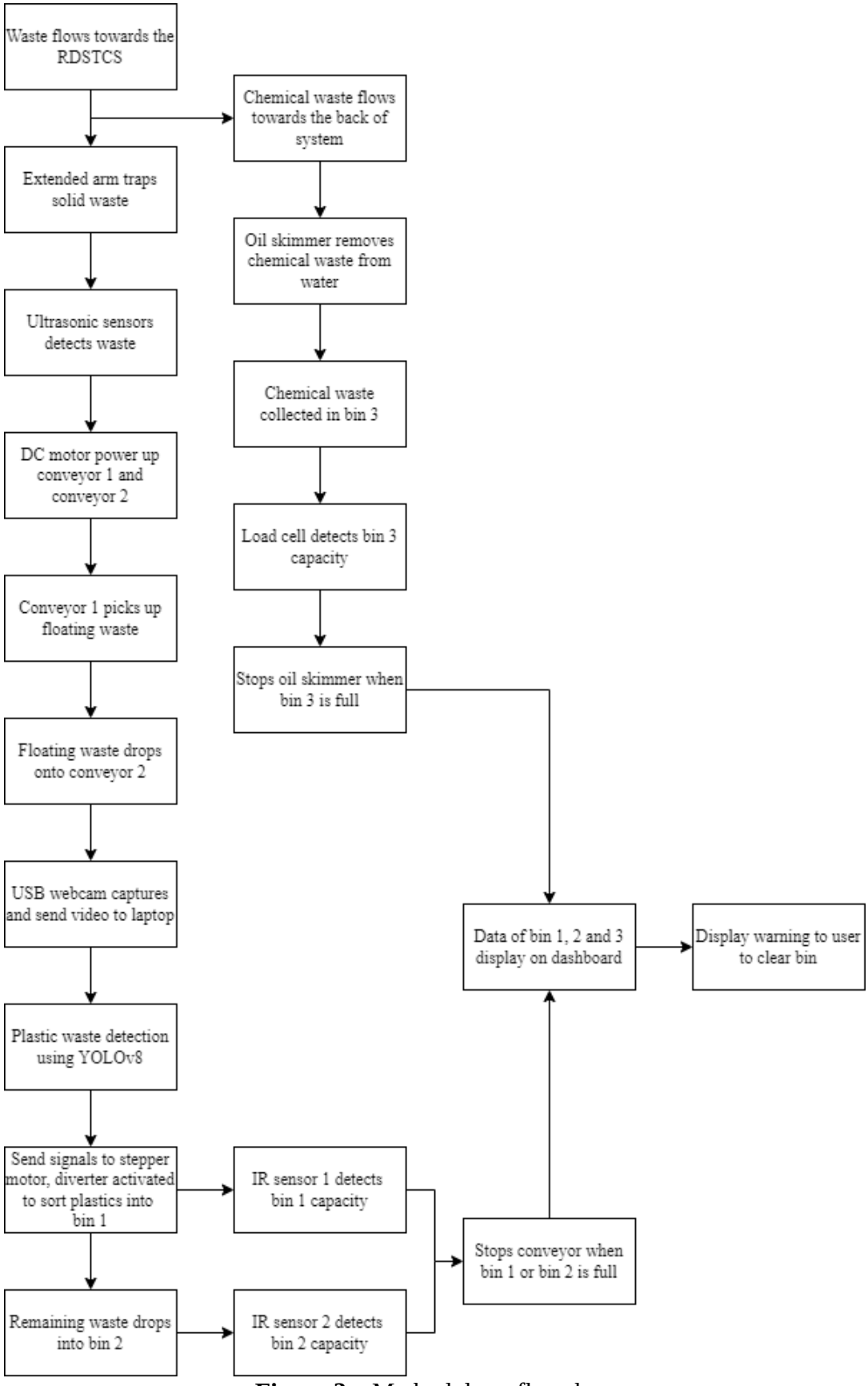


Figure 3 – Methodology flowchart

C. Wiring diagram and Components

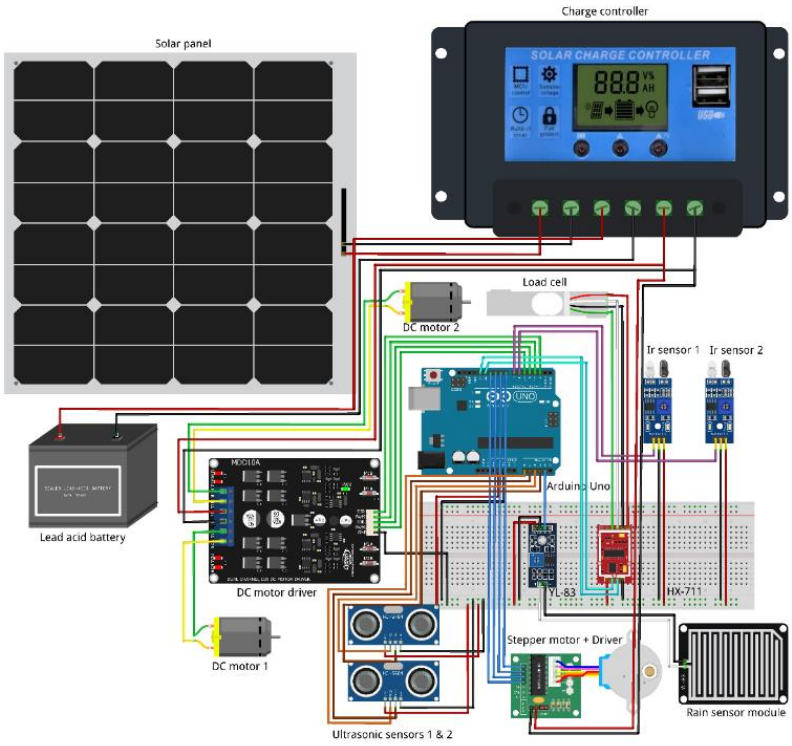


Figure 4 – Wiring diagram

The circuit connection of the electrical components is shown in Figure 4 above, where the components are listed in Table 1 below.

Table 1 – List of components

No.	Component	Quantity
1	Arduino Uno	1
2	HC-SR04 Ultrasonic Sensor	2
3	FC-51 IR Sensor	2
4	YL-83 Rain Sensor Module	1
5	10kg Load Cell	1
6	HX711 Module	1
7	28BYJ-48 Stepper Motor + ULN2003 Driver	1
8	MDD10A Motor Driver	1
9	5840-31ZY-12V 80RPM DC Motor	1
10	JGY-370-12V 90RPM DC Motor	1
11	Koshi 12V 12Ah Sealed Lead Acid Battery	1
12	20A Charge Controller	1
13	50W Solar Panel	1

For the overall workflow of the system, the waste removal process starts with the extended arm made of PVC strip curtain trapping the floating debris flowing towards the system, while allowing chemical waste flow towards the back of the system through holes on the extended arm. Floating debris will then be extracted from the water surface using a conveyor mechanism, where a USB webcam is used to capture the video of the waste collected, sending

the captured video to a laptop to perform real-time detection to identify recyclable plastics using YOLOv8 algorithm.

Once recyclable plastic waste is identified, a signal willbe sent from Python to Arduino Uno in order to activate the stepper motor. With the diverter attached to the motor, it allows target plastic object to be pushed into bin 1. Besides, for non-recyclable waste, diverter will be retracted, allowing the waste to be dropped into bin 2. While on the other end of the system, chemical waste will be collected using an oil skimmer with a rotating acrylic disc into bin 3. A 50W solar panel is used to supply clean energy towards the RDSTCS.

A. Conveyor control

Two HC-SR04 ultrasonic sensors were installed at the front of the system to perform waste detection. An ultrasonic sensor is a device used to detect the presence of objects through sound waves, where the travel time of the wave can also be used to calculate the distance to the object. As sound waves can penetrate through water, ultrasonic sensors can be utilized in this application to detect the presence of waste on the water surface. As for the first ultrasonic sensor, when the distance value falls below a predefined threshold, it indicates that floating debris is present in front of the conveyor. Hence, the DC motor will be activated to power up the conveyor, improving the energy efficiency of the system.

Similarly, the second ultrasonic sensor is used to detect the presence of waste further away from the conveyor. This aims to detect the accumulation of waste, which coincident detection by both sensors indicates a potential of waste overflow. Hence, the speed of the conveyor will be increased to facilitate a faster waste extraction rate.

Besides, as the rate of waste flowing into rivers and drains tends to increase during rainy days, YL-83 rain sensor module is implemented into the design, where the conveyor speed will be increased to reduce the risk of trash overflow during rainy days.

B. Plastic detection

Machine vision is employed for real-time identification of recyclable plastic waste. To achieve this, a dataset containing images of recyclable plastics such as plastic bottles, bottle caps and plastic food containers was annotated using the Computer Vision Annotation Tool (CVAT). A total of 1,158 images for training and 283 images for validation were used to train a YOLOv8n model for recyclable plastic detection.

C. Dashboard

A dashboard is created to allow the user to monitor the capacity of each bin in real-time. To identify the capacity of bin, infrared sensors are installed on each of the solid waste collecting bins, which are bin 1 and bin 2. This allows the detection of bin capacity, where the conveyor will be stopped when one of the bins is full.

While for the oil skimmer bin that collects chemical waste, bin 3, a load cell is installed under the bin, which can measure the weight of the chemical waste collected and stop the oil skimmer when it reaches its maximum capacity. All the data from the infrared sensors and load cell is sent back from Arduino to Python, where an online dashboard is then created using Streamlit. A warning will also be displayed to the user when any of the bin reaches the

maximum capacity. This dashboard can be accessed by devices that are connected to the same network.

RESULTS AND DISCUSSION

This section discusses the field testing results of the RDSTCS to verify the functionality of the final prototype. To test the prototype, the RDSTCS is placed in a controlled setting, which is a swimming pool, where the pattern of waste flowing towards the system is replicated to simulate the working principle of the system when being placed in a river or drain.

A. Final prototype

Figure 5 – Final prototype

Figure 5 above shows the final prototype design of the RDSTCS. The system can successfully float at the desired water level, where floating debris and chemical waste can be extracted efficiently from the water surface. For the rate of floating waste extraction of the system, plastic bottles are selected as the standard unit of measuring, which the maximum rate is tested to be 7 bottles per minute when the conveyor DC motor is operating at 80RPM. While for the rate of chemical waste extraction, the system is capable of removing 0.104kg of chemical waste per minute when the oil skimmer DC motor is operating at 45RPM.

B. Plastic detection

To verify the accuracy of the model trained, testing is performed by feeding 9 different type of waste that are commonly found on water surface towards the system, which are shown in Figure 6 below. The plastic detection model testing is performed by feeding each type of waste to the RDSTCS for 10 times each. The detection results are split into 2 categories, which is recyclable plastics that should be detected by the machine vision model, and non-recyclable objects which should not be detected by the model. The results of the detection are shown in Table 2 and Table 3 below.

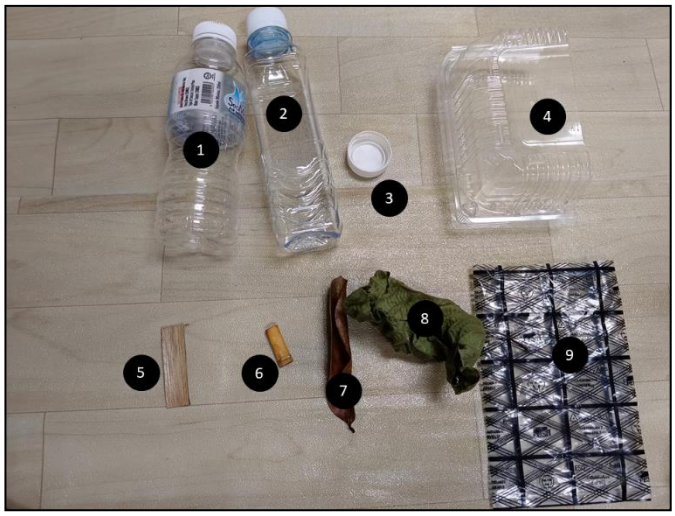


Figure 6 – Waste used for plastic detection testing

1. Plastic bottle 1
2. Plastic bottle 2
3. Bottle cap
4. Plastic container
5. Wood
6. Cigarette butts
7. Dried leaf
8. Leaf
9. Plastic bag

Table 2 – Plastic detection result for recyclable plastics

Type of waste	Total number of tests	Detected as recyclable plastic	Not detected as recyclable plastic	Accuracy
Plastic bottle 1	10	10	0	100%
Plastic bottle 2	10	10	0	100%
Bottle cap	10	10	0	100%
Plastic container	10	9	1	90%

Table 3 – Plastic detection result for non-recyclable objects

Type of waste	Total number of tests	Detected as recyclable plastic	Not detected as recyclable plastic	Accuracy
Wood	10	0	10	100%
Cigarette butts	10	0	10	100%
Dried leaf	10	0	10	100%
Leaf	10	2	8	80%
Plastic bag	10	4	6	60%

According to the results shown in Table 2 and Table 3, they show that all the detection accuracy of recyclable plastics are high, which indicates that the trained model can accurately identify recyclable plastics from other waste. While for the plastic detection result for non-recyclable objects, some objects have a slightly lower accuracy, such as leaves and plastic bags. This can happen due to the fact that in the dataset of recyclable plastic, some images contain plastic bottles that have the similar color as leaf, which can result in a false detection of leaf as recyclable plastics. On the other hand, plastic bags have similar visual characteristics to recyclable plastics in terms of transparency. Hence, this can also cause false detection by the plastic detection model.

C. Sorting

For the experimental setup for sorting mechanism testing, plastic bottle 1, plastic bottle 2, bottle cap and plastic container are used to perform the testing as only recyclable plastics are required to be sorted with the help of the sorting mechanism. Each type of recyclable plastic will be tested for 10 times, with 2 different conveyor speeds as the DC motor speed varies based on feedback from the ultrasonic sensors, which are 40RPM and 80RPM. The sorting mechanism is shown in Figure 7 below, along with the result of sorting in Table 4 and Table 5 below.

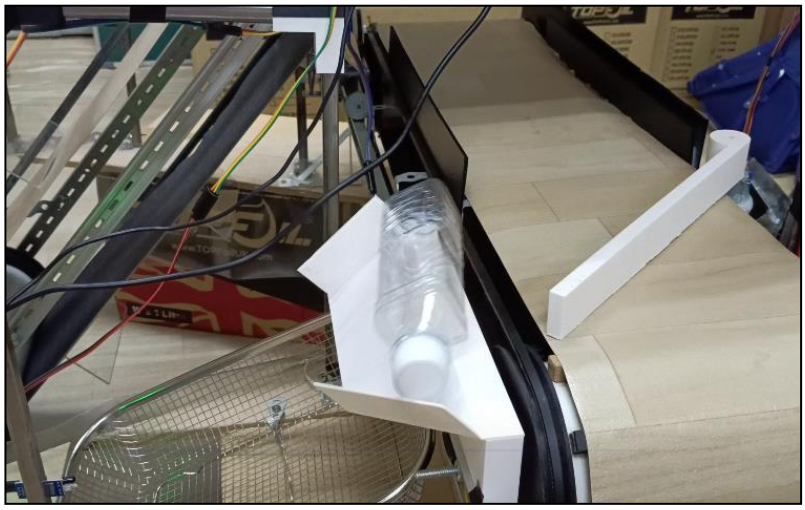


Figure 7 – Sorting mechanism

Table 4 – Sorting result at 40RPM

Type of waste	Total number of tests	Number of successful sorting	Number of unsuccessful sorting	Success rate
Plastic bottle 1	10	10	0	100%
Plastic bottle 2	10	7	3	70%
Bottle cap	10	0	10	0%
Plastic container	10	6	4	60%

Table 5 – Sorting result at 80RPM

Type of waste	Total number of tests	Number of successful sorting	Number of unsuccessful sorting	Success rate
Plastic bottle 1	10	10	0	100%
Plastic bottle 2	10	8	2	80%
Bottle cap	10	0	10	0%
Plastic container	10	8	2	80%

According to the result above, it is shown that the success rates for plastic bottle 1 and plastic bottle 2 are acceptable. However, for bottle cap, the success rate of sorting is 0%. This is due to the fact that the small size of bottle cap can easily get stuck in the gap between the conveyor belt and the pulleys, resulting in an unsuccessful sorting. While for plastic container, the success rate is 60%. This occurs due to the large size of the container, in which the diverter can sometimes block the movement of the container when it fully extends. By comparing both the results of sorting at 40RPM and 80RPM, it can be observed that the success rate of a certain type of object increases when the DC motor speed increases. This can happen due to the increase in external forces from the conveyor movement, which helps in pushing the waste towards the bin with the help of a diverter.

CONCLUSION

This paper presents the construction of the RDSTCS prototype, which is able to remove pollutants from the water source to fulfil Goal 14 of the Sustainable Development Goals (SDG), Life Below Water. Through the testing conducted, it is proven that the system designed is capable of collecting floating waste and chemical waste. Machine vision is also implemented into the design to perform recyclable plastic sorting, which causes the system to be more efficient in the waste management process compared to the existing waste collecting system.

Table 6 – Comparison between the existing system and the proposed system

No.	Features	Existing system	Proposed system
1	Solid waste collecting	YES	YES
2	Chemical waste collecting	YES	YES
3	Automated conveyor control	-	YES
4	Automated sorting	-	YES
5	Dashboard	-	YES

To further enhance the functionality and reliability of the RDSTCS proposed, IR sensors can be added at the conveyor to detect the height of the waste extracted to tackle with the issue where transparent plastic bags can often be falsely detected as recyclable plastics. As the height difference between plastic bags and plastic bottles is easily distinguishable, an appropriate vertical placement of an IR sensor can help the RDSTCS to better differentiate between plastic bags and plastic bottles. For practical use cases of the RDSTCS, the capacity of the bin should be increased in order to handle larger waste volumes.

REFERENCES

BABBAR, S. M., & LAU, C.-Y. (2020). Medium term wind speed forecasting using combination of linear and nonlinear models. *Solid State Technology, 63*(1s), 874-882.

Babbar, S. M., & Yong, L. C. (2023). *Short term solar power forecasting using deep neural networks.* Paper presented at the Future of Information and Communication Conference.

Cheng, K. M., Zaini, A. M., Marei, M. A. M. A., Koo, A. C., Tan, K. G., & Zaini, J. S. M. (2022). *The Edcraft Catalogue: Collaboration of Artist and Academic in "Waste to Craft" Gamified Activity.* Paper presented at the 2nd International Conference on Creative Multimedia 2022 (ICCM 2022).

HUANG, Z.-J., & LAU, C.-Y. (2020). Camera Vision Foreground Detection Employing Frame Differencing And Background Subtraction In Solar Farm Monitoring Application. *Solid State Technology, 63*(1s), 883-892.

Kabir, Z., & Kabir, M. (2021). Solid waste management in developing countries: towards a circular economy. In *Handbook of Solid Waste Management: Sustainability through Circular Economy* (pp. 1-34): Springer.

Pierson, T. C. (1992). *Immediate and long-term hazards from lahars and excess sedimentation in rivers draining Mt. Pinatubo, Philippines* (Vol. 92): US Department of the Interior, US Geological Survey.

Sadhukhan, B. (2020). Integrated rural urban water management for climate based adaptations in Indian cities (IAdapt): final technical report.

Sing, A. L. C., Vasudavan, H., & Jabbar, K. A. (2023). *An Evaluation of Integrating Ubiquitous Computing and Sustainable Practices for Malaysia's Flood Prevention System.* Paper presented at the 2023 IEEE 21st Student Conference on Research and Development (SCOReD).

Singh, S., Rai, S., Singh, P., & Mishra, V. K. (2022). Real-time water quality monitoring of River Ganga (India) using internet of things. *Ecological Informatics, 71*, 101770.

Thea, S., Lau, C. Y., & Lai, N. (2022). Automated IoT Based Air Quality Management System Employing Sensors and Machine Learning. *Journal of Engineering Science and Technology, 2022*, 172-184.

YAKUBU, J. A. (2017). *THE WASTE MANAGEMENT SYSTEM IN LOW INCOME AREAS OF JOS, NIGERIA: THE CHALLENGES AND WASTE REDUCTION OPPORTUNITIES: APPENDICES.* University of Brighton,

APPLICATION OF IMAGE PROCESSING FOR SIGN LANGUAGE INTERPRETER

Ng Thung Xeng[A], Hafizul Azizi bin Ismail[B], Yvette Shaan Li-Susiapan[C], Lau Chee Yong[D], Sathish Kumar Selva Perumal[E], and Ittidej Moonmangmee[F]

ABSTRACT

The aim of this project is to develop a sign language interpreting system that interprets and translates American Sign Language (ASL) into English words and sentences through machine vision and machine learning. In the proposed methodology, algorithms for data augmentation and data preprocessing as well as model training and evaluation are developed along with the system's Graphical User Interphase (GUI). 3 different models are trained while developing the system, LSTM, Bi-LSTM and GRU and among them, GRU achieves the highest training accuracy of 95.14% and evaluation accuracy of 95.56% hence it is implemented into the system. By testing it in real-time, the system is able to make predictions in 0.143 seconds with 98.79% confidence. Through other various tests, the system proved its capability to produce equally accurate predictions in real-time regardless of the signer's position, distance and hands used. The system is also able to translate ASL sentences into grammatically sound English sentences through OpenAI API.

Keywords: *LSTM, GRU2, American Sign Language 3, Bi-LSTM, Signal Processing*

INTRODUCTION

Sign language is a complex form of communication used by deaf people around the world. There are over 300 different sign languages, each with its own unique signs and grammar. Sign languages are developed from existing spoken languages, but they do not express words directly. Instead, sign languages express meaning through gestures. Sign gestures are divided into two types: static and dynamic. Static gestures involve only handshapes, while dynamic gestures involve both handshapes and body movements. Dynamic gestures are used to represent both words and phrases (Roy et al., 2019). One of the biggest challenges faced by the deaf community is communication barriers. Many hearing people do not know sign language, which can make communication difficult. In the United States, for example, less than 1% of the population knows ASL. There are existing systems that can

[A] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: ngthungxeng@gmail.com*
[B] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: hafizul.azizi@apu.edu.my*
[C] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: shaan@apu.edu.my*
[D] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: laucheeyong@apu.edu.my Orcid: https://orcid.org/0000-0001-7174-4953*
[E] *School of Engineering, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: sathish@apu.edu.my*
[F] *Ph.D., School of Science and Technology, Sukhothaithammathirat Open University, Thailand.*

translate sign language into words (More et al., 2018). These systems use sensors to track hand movements and predict what is being signed. However, these systems can be complex and uncomfortable to use (Anthoniraj et al., 2021). This project aims to develop a sign language translator that is easier to use. The translator will use machine vision and AI to interpret ASL and translate it into English words. This will allow people with limited ASL knowledge to communicate with deaf people more easily (Swamy et al., 2014).

Objectives:

- To design a vision-based sign language algorithm with machine vision and key point detection tools.
- To develop a sign language interpreting model by training it with datasets collected online.
- To evaluate the accuracy of the sign language translator by testing it with real-time data.

A study from 2019 shows that 25% of deaf adults are diagnosed with depression or anxiety disorder. This is often due to social isolation, as many hearing people do not understand sign language. The sign language translator developed in this project could help to reduce social isolation for deaf people (Vedak et al., 2019).

PROPOSED METHODOLOGY

Feature extraction

To extract features regarding the position, motion, shape and orientation of the signer's hands and arms, an open-source framework developed by Google called MediaPipe will be used. Within the MediaPipe framework, there are pretrained models that could detect the key-points of a person's body, hands, and face in a 3-dimensional space as shown in Figure 1.

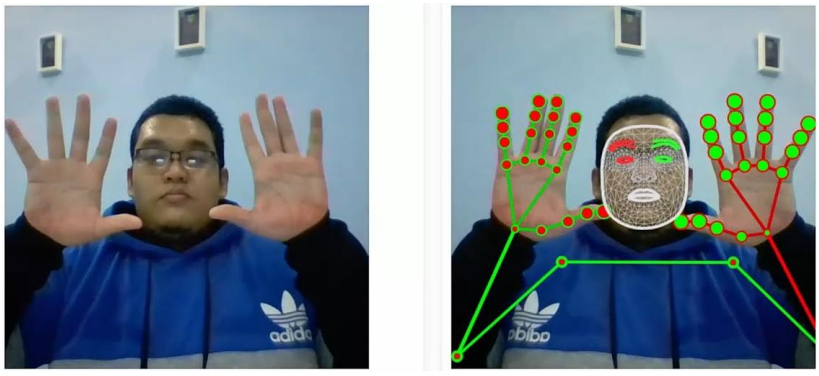


Figure 1 – K ey-point detection with MediaPipe

By performing feature extraction with MediaPipe pretrained models, the X, Y and Z coordinates of the key-points will be returned as a numpy array. The number of key-points for the face are much larger compared to the hands and body. If the key-points of the face are extracted, it will increase the size and complexity of each training data. This would in turn increase the time and computational cost for training the model. Hence, in this project, only the key-points of the body and hands of the signer will be extracted. Furthermore, the facial expression of the signer is of less significance compared to the motion and shape of the hands and arms of the signer (BABBAR & LAU, 2020).

There are 21 key-points that can be detected by the MediaPipe hands detection model on each hand. Since the coordinates of the key-points are in 3-dimensional space, there is a total of 126 data points for both hands as shown in Figure 2.

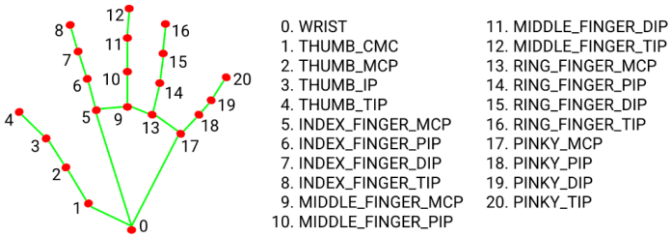


Figure 2 – Hand key-points detected by MediaPipe

Key-points on each hand * Number of hands * 3-dimension coordinate
= 21 * 2 * 3 = 126 data points

For the body, 33 key-points can be detected by the MediaPipe pose detection model. To simplify the training data, only the key-points of the upper body including the arms and shoulders are extracted since the lower body is not important when interpreting sign language. In order to reduce redundant data, the key-points of the hands are not extracted since a higher resolution of hand key-points are captured by the previous MediaPipe hands detection model (Babbar & Yong, 2023). In conclusion, only 17 key-points will be extracted which includes the facial features, shoulders, elbow, and wrist (Dissanayake et al., 2020). According to the documentation, these landmarks are indexed as 0 to 16 by MediaPipe as shown in Figure 3.

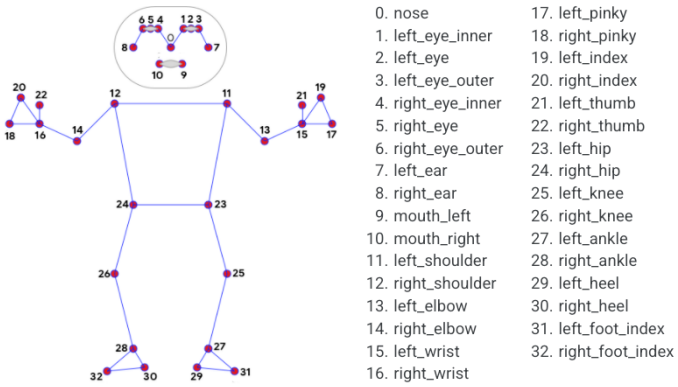


Figure 3 – Body key-points detected by MediaPipe

3. Concept design

- **LSTM**

LSTM (as shown in Figure 4) is an extension of RNN with a cell state in addition to the hidden state. The cell state acts as a memory where previous and current information is stored. Information flowing through the cell state is governed by gates, which are composed of sigmoid functions that return values between 0 and 1. There are three gates in an LSTM: forget gate, input gate, and output gate. When input is fed into LSTM, it first passes through the forget gate, which determines whether to keep or discard the previous information based on the new input information. Then, the input gate quantifies the importance of the input information before updating the cell state. Finally, the output gate determines what information will be carried over

into the next hidden state, which is used to predict the sequence of data (HUANG & LAU, 2020).

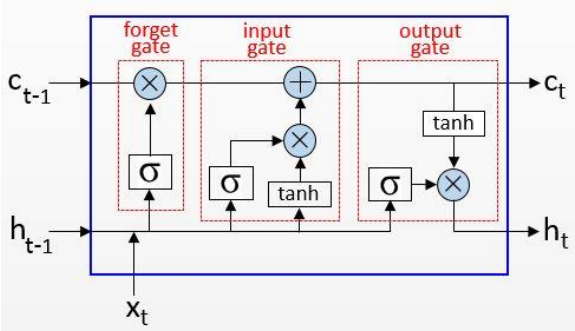


Figure 4 – Gates within LSTM

Due to the presence and regulation of cell state, LSTM can make accurate predictions on long and complex sequences.

- **Bidirectional-LSTM**

Bidirectional-LSTM (as shown in Figure 5) is made by combining two layers of LSTM. One layer processes the input in a forward direction (past to future), while the other layer processes the input backwards (future to past). This allows the model to preserve both past and future information, which is useful for making predictions on sequential data, especially for natural language processing where word meanings are contextual and depend on both preceding and proceeding words. Bidirectional-LSTM can also be used in sign language translation to produce a more accurate result compared to unidirectional-LSTM. However, due to the extra layer of LSTM in each hidden layer, bidirectional LSTM takes longer to process data compared to unidirectional LSTM (Thea et al., 2022).

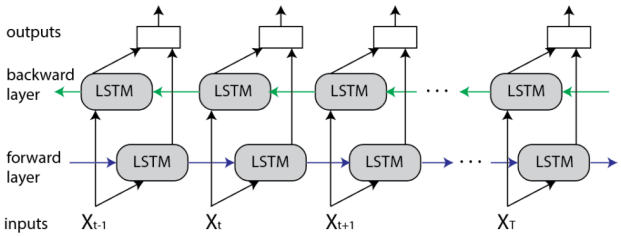


Figure 5 – Bidirectional-LSTM

- **GRU**

GRU (as shown in Figure 6) is an extension of RNN with only two gates. It combines the forget gate and input gate of LSTM into a single update gate, which determines how much current and prior information should be passed to the next hidden state. The reset gate decides how much information to discard. GRU is more compact than LSTM due to its fewer gates, resulting in reduced parameters and processing time while retaining information dependency. However, GRU may not perform as well as LSTM for long-term dependencies or highly complex sequential patterns due to its reduced architecture complexity and parameters (Nath & Arun, 2017).

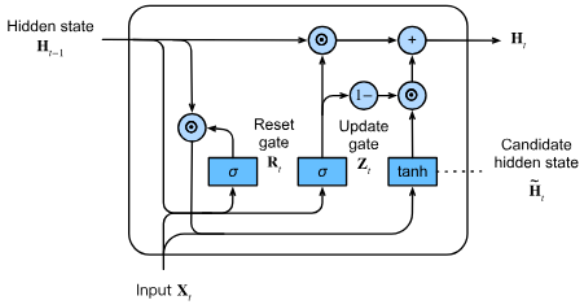


Figure 6. Gates within GRU

1.1 Overall block diagram for model development

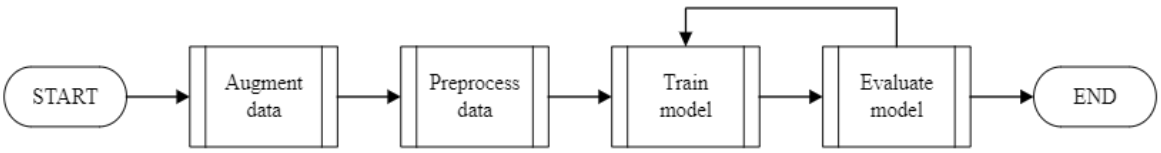


Figure 7 – Model development block diagram

Firstly, the dataset is augmented to increase its size and diversity. Then, the augmented data is preprocessed to standardize, clean and organise the data. The preproccesed data is then used to train 3 different models, LSTM, Bi-LSTM and GRU. After that, the models are evaluated with testing data and based on the evaluation and training results, the model's hyperparameters are tuned before it is retrained and reevaluated until a high training and validation accuracy is achieved. After the models are trained and evaluated, the model with the highest validation accuracy will be used to make predictions. The process is Illustrated in Figure 7.

1.2 Overall block diagram for implemented sign language interpreting system

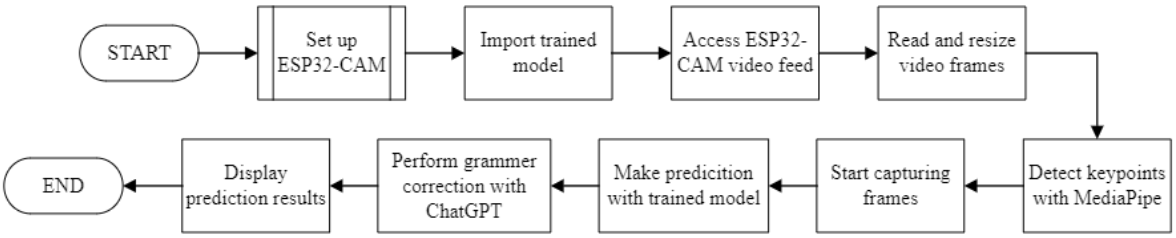


Figure 8 – Sign language interpreting system block diagram

Figure 8 is showing the sign language interpreting system block diagram. Before making predictions, the ESP32 camera module is set up in Arduino IDE to capture video frames. Next, the trained model is imported into the system. The video frames captured by ESP32-CAM is then accessed before it is read and resized. Within the resized video frames, the key-points of the signer's hands and body are detected by MediaPipe. On the user's command, the system starts capturing video frames. When sufficient video frames are captured, the trained model makes prediction based on the sequence of video frames. The grammar of the sentence generated is then corrected by ChatGPT before it is displayed to the user.

1.3 Data augmentation

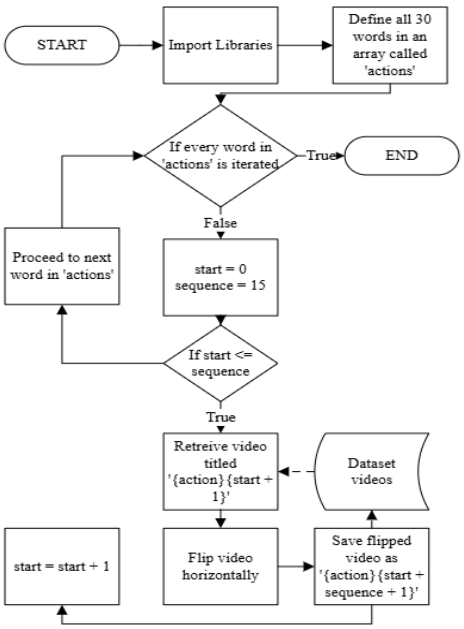


Figure 9 – Data augmentation flowchart

Figure 9 shows the logic and process of the data augmentation algorithm. After importing necessary liabraries, all 30 words that the model will be trained to recognise is defined in an array called ‘actions’. Then, the algorithm enters the first loop in which it checks if every word in the ‘actions’ array is iterated or not. If not, the alrogithm then enters the second loop in which the video corresponding to the current word and index is retrived from the dataset. After retriving the video, it is flipped horizontally and saved back into the dataset as a new video with a new index. Then, ‘start’ is incremented by 1 before the process is looped again. This loop will stop when the value of ‘start’ is more than ‘sequence’ and once that happens, the algorithm proceeds to the next word in the ’actions’ array before returning to the first loop. Once every word in the ‘actions’ array is iterated, the algorithm ends.

Each dataset videos are flipped horizontally and saved into the same dataset. As a result, the size of the original dataset doubles after data augmentation. In total, the dataset contains 900 videos across all 30 words.

1.4 Data preprocessing

The data preprocessing algorithm is shown in Figure 10. It begins by importing libraries and defining the data path. It then enters a loop that iterates through each word in the actions array. For each word, it creates folders named after the word and sequence and generates 30 sequence folders within them. Once all words are iterated, the algorithm proceeds to set up the MediaPipe model for key-point detection.

After setting up, the main loop is initiated, and the algorithm checks if every word in the actions array has been iterated. If not, it enters a nested loop where it retrieves the video corresponding to the current word and sequence from the dataset. It calculates the total number of frames in the video and the frame capturing interval. Then, an inner nested loop is initiated, where the algorithm navigates to the corresponding frame of the video, reads the frame, resizes

it, and uses MediaPipe to detect and extract the key-points of the signer within the frame. The extracted keypoints are saved to the data path, and the frame number is updated. This inner nested loop continues until the required number of frames is captured. The outer nested loop then proceeds to the next video, and the entire process repeats until all videos for the current word are processed. When all words in the actions array are iterated, the algorithm ends.

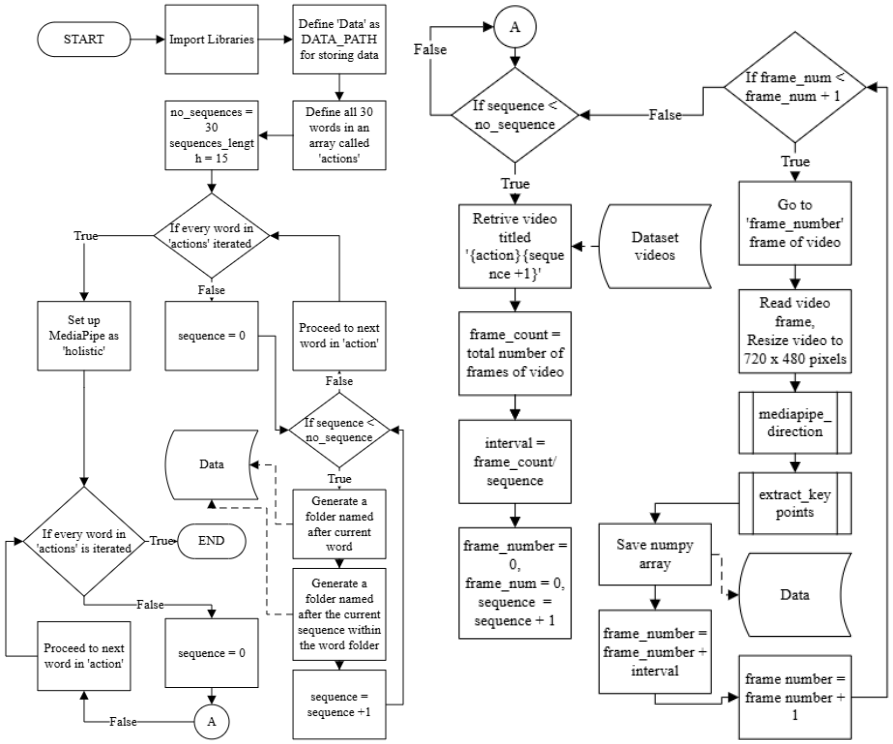


Figure 10 – Data preprocessing flowchart

For extract keypoints, the function first places the 3D-coordinates of the detected keypoints into an array called pose. Then, the zero-point and fixed depth are established. The coordinates in pose are made relative to the zero-point and fixed depth, and the results are placed into a new array called pose_zero. After that, the first 17 keypoints in pose_zero are extracted and placed into another array called pose_zero_upper. The same process is repeated for the left and right hand of the signer, where the standardized 3D-coordinates of the detected keypoints are placed into arrays called left_hand and right_hand respectively. Finally, the function returns a concatenated array of pose_zero_upper, left_hand, and right_hand to the main algorithm. The array is illustrated in Figure 11.

```
[ 0.          0.         -0.8         0.01450038 -0.039324   -0.7662444   0.02402705 -0.04018924 -0.76629393  0.03242683 -0.04089651 -0.76627045
 -0.01358199 -0.03783748 -0.76941453 -0.02296695 -0.03733957 -0.76953589 -0.03202605 -0.03644876 -0.76984899  0.04391026 -0.02914982 -0.48626177
 -0.04414633 -0.0232885  -0.50608968  0.01915944  0.03775343 -0.69015698 -0.01725623  0.03718767 -0.69490223  0.13267672  0.21096554 -0.28920554
 -0.11864799  0.20304123 -0.28307109  0.18377036  0.53912127 -0.13768007 -0.19553027  0.50322568 -0.48132085  0.18128085  0.81441897 -0.33463876
 -0.13547641  0.42414564 -1.03052251  0.          0.          0.          0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.         -0.14876118  0.46611494  0.02227289 -0.15869483  0.49984086  0.00433447
 -0.15749687  0.53449267 -0.00979086 -0.15740401  0.56731683 -0.02131547 -0.16058388  0.58720881 -0.03312427 -0.12014076  0.54029286 -0.01409998
 -0.10475859  0.58457226 -0.02928537 -0.09729528  0.61154217 -0.03870136 -0.09092239  0.63593841 -0.04487386 -0.10030618  0.52632451 -0.012196
 -0.0749746   0.57770443 -0.02531962 -0.06195846  0.60953808 -0.03127067 -0.05205041  0.6358093  -0.03582321 -0.08685079  0.51097775 -0.010713
 -0.06043684  0.55983973 -0.02144561 -0.04822052  0.59180611 -0.02618439 -0.04009971  0.61848378 -0.0295251  -0.07897681  0.49519914 -0.01034685
 -0.05660859  0.53132957 -0.01841587 -0.04728213  0.55623728 -0.02117547 -0.04207429  0.57769668 -0.02318405]
```

Figure 11 – C oncatenated array

1.5 Model training and evaluation

The algorithm imports libraries, defines the data path, and creates an array of 30 words. It then iterates through each word, labeling it as 'num', and enters a nested loop. Within the inner loop, it loads the corresponding numpy array, appends it to 'sequences', appends the label to 'labels', and updates 'frame_num'. This process continues until 'frame_num' is no longer less than 'sequence_length'. The outer loop then repeats until 'sequence' is no longer less than 'no_sequence'. After the main loop, 'sequences' and 'labels' are stored as 'X' and 'y', respectively. These are then split into training and testing data. The training data is used to train the model, and the testing data is used to evaluate its performance. Finally, the evaluation results are displayed.

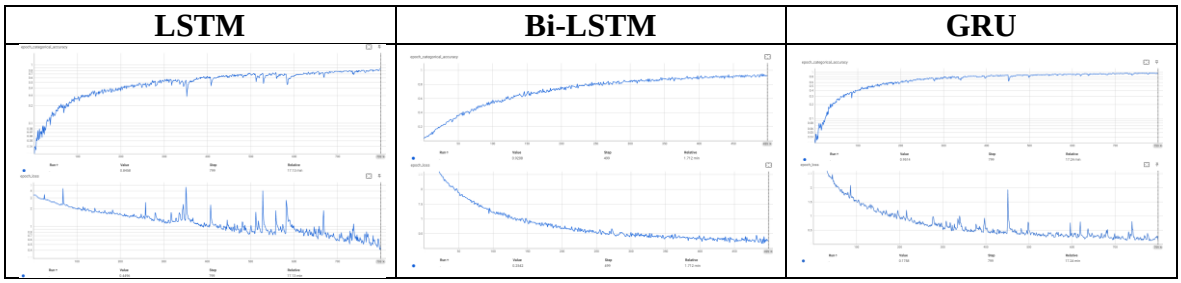


Figure 12 – Training result of each model

By referring to the training results of each model as shown in Figure 12, GRU achieved the highest accuracy of 95.14%. After evaluating each model and analyzing the evaluation matrices, GRU also achieved the highest validation accuracy. Since GRU achieved the highest training and validation accuracy amongst the 3 model, this model is selected to be implemented in the final sign language interpreting system to make predictions in real-time.

TESTING

1. Testing of proposed design

In this section, the sign language interpreting system is first be tested on how well it performs in real-time. Next, the robustness of the system is tested by subjecting it under various situations including the varying positions and distance of the signer relative to the camera, the hands used by the signer to perform ASL and the brightness level of surroundings.

1.1 Real-time predictions

For this test, the signer is required to be 1 meter (m) away from the camera and be positioned at the centre of the frame under a brightness level of 40 Lux (lumen per square meter). The signer then signs 10 random words from Table 3.4 and the prediction results are recorded. This process is repeated 2 more times to obtain the average accuracy and confidence of the system across the 10 words. The model managed to predict all 10 words correctly. Based on Figure 5.1, the prediction confidence of the system across all 10 words is at least 96% on average. Overall, the system has a prediction confidence of 98.79% with an average processing time of 0.143 seconds as shown in Figure 13.

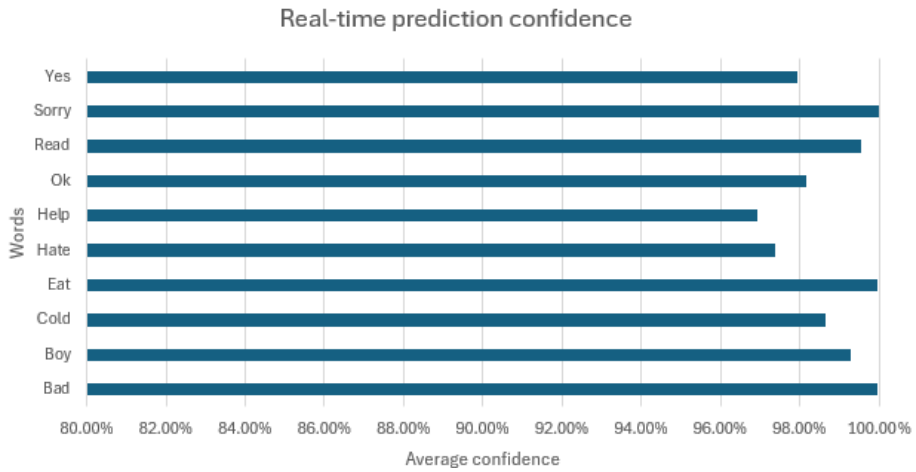


Figure 13 – Real-time prediction confidence

1.2 Hands used by signer

The signer must be 1m away from the camera and positioned at the centre of the frame under 40 Lux. Next, 10 random words that requires only one hand to sign are selected from Table 3.4. The words are then signed by the signer first with his left hand, then again with his right hand. This process is repeated 2 more times to determine the system's average accuracy and confidence across the 10 words as shown in Figure 14.

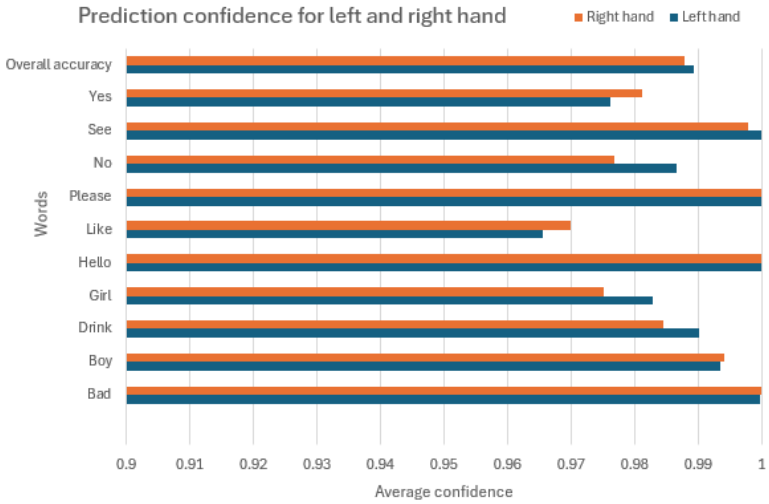


Figure 14 – Prediction confidence for left and right hand

The model is able to accurately predict all 10 words for left and right hand. Based the results plotted in Figure 5.2, it can be observed that the prediction confidence across all 10 words signed by left or right hand are similar. Amongst the 10 words, 'no' has the biggest difference in terms of confidence, which is only 0.98%. The overall confidence of the system in interpreting words signed by left or right hand only have a difference of 0.15%. In conclusion, this system is capable of interpreting ASL regardless of which hand is being used by the signer.

1.3 Position of signer

The signer is required to be 1m away from the camera for this test and under 40 Lux. Then, the signer is positioned in the center of the frame and 5 random words from Table 3.4 are

signed. Next, the 5 random words are signed again but the signer is positioned on the far left of the frame. This process is repeated once more with the signer positioned on the far right of the frame. The prediction results of the system and its accuracy and confidence are recorded and tabulated throughout this test as shown in Figure 15.

Figure 15 – Prediction confidence for different position of signer

The model proved to be able to make accurate predictions across all 5 words when the signer is in all 3 positions. By referring to the results plotted in Figure 5.3, the prediction confidence across all 5 words when the signer is in varying position are relatively similar, the biggest difference being only 0.56%. After this test, it can be concluded that this system is able to interpret ASL regardless of the signer's position within the frame.

1.4 Distance of signer

For this test, the signer is required to be positioned at the center of the frame and under 40 Lux. Then, the signer is positioned 0.5m away from the camera before 5 random words from Table 3.4 are signed. This process is repeated with the distance of the signer from the camera changed to 1m, 1.5m and 2m. Throughout this test, the system's prediction results are recorded and tabulated as shown in Figure 16.

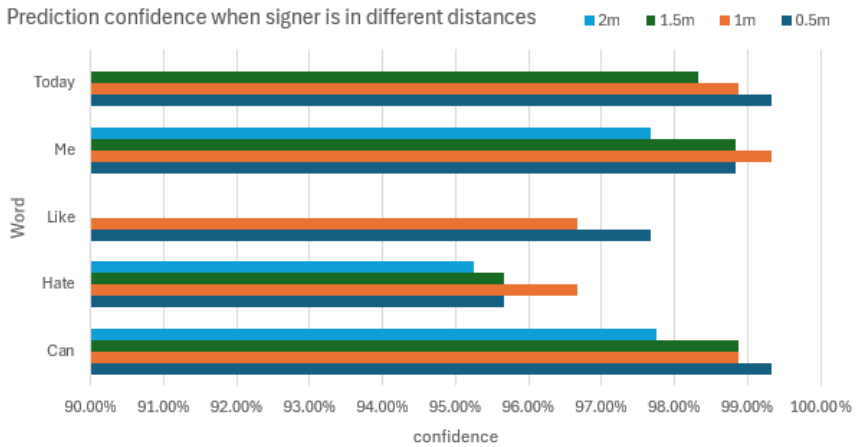


Figure 16 – Prediction confidence different distance of signer

The system is able to produce accurate predictions with over 95% confidence for the words ‘me’, ‘hate’ and ‘can’. For the word ‘like’, the system predicts ‘please’ once the signer is at 1.5m or further whereas for the word ‘today’, the system predicts ‘can’ when the signer is at 2m away from the camera. These incorrect predictions are due to the low resolution of the ESP32 camera module which gives MediaPipe difficulties in detecting the signer’s key-points accurately.

1.5 Brightness level

The signer is required to be 1m away from the camera and be positioned at the center of the frame for this test. Then, 3 random words are signed by the signer under a brightness level of 5 Lux and the prediction results are recorded. This process is repeated with the brightness level incrementing by 5 Lux each time upwards to 30 Lux.

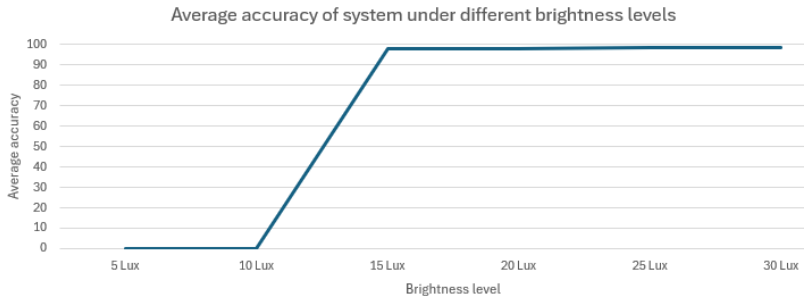


Figure 17 – Prediction confidence under different brightness level

The system has an average confidence of 0% but at 15 Lux and above, the system’s average confidence is about 98%. At low brightness levels, the ESP32 camera module is unable to clearly capture the signer, hence, no key-points are detected by MediaPipe which means no prediction can be made by the system. In conclusion, this system can only perform well under brightness levels of 15 Lux or higher as shown in Figure 17.

Comparison with other research

Table 1 – Accuracy of other systems

Arthur	Model	Accuracy (%)
Stylianos K. Psara	GRU	89.03
Gerges H.Samaan et al.	GRU	100
Shamita S H & Dr. Badarinath K	LSTM	97
Ridwang	GRU	85
Bushra A. Al-Mohimeed et al.	CNN-LSTM	70
This project	GRU	95.56

The accuracy of other models developed by other researchers that was reviewed. The performance of the model surpasses most of researcher’s model apart from Gerges H.Samaan et al. and Shamita S H & Dr. Badarinath K in which their model is able to achieve 100% and

97% accuracy respectively. This is because their model is only trained to recognize 10 and 24 words respectively which is significantly less than the 30 words that my model is trained to recognize. The comparison is tabulated in Table 1.

By looking into the systems developed by the researchers, there is a of lack features such as successive predictions and grammar correction which restricts the user from constructing grammatically sound sentences with ASL. My system however is able to make predictions successively and apply grammar correction to the constructed sentences which makes understanding ASL sentences a lot easier.

CONCLUSIONS AND RECOMMENDATIONS

In order to achieve the objectives of this project, a vision-based sign language interpreting algorithm that utilizes OpenCV for machine vision and MediaPipe for keypoint detection is designed. Next, 3 different models, LSTM, Bi-LSTM and GRU are developed and trained with the dataset collected online which yields a training accuracy of 84.58%, 92.08% and 95.14% respectively. The accuracy of the 3 models is then evaluated with testing data and amongst them, GRU achieves the highest accuracy of 95.56%. The GRU model is also tested in real-time under various conditions. Through the conducted tests, it is determined that the GRU model can make predictions in real-time with 98.79% confidence regardless of the signer's position the frame or the hands used. The test results also suggest that for optimal performance, the signer should be 1 meter away from the camera with a minimum brightness level of 15 Lux.

REFERENCES

Anthoniraj, S., Ganashree, V., Umdor, B. J. R., Sai, G. D., & Navya, B. (2021). Sign Language Interpreter Using Machine Learning. 2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA),

BABBAR, S. M., & LAU, C.-Y. (2020). Medium term wind speed forecasting using combination of linear and nonlinear models. *Solid State Technology, 63*(1s), 874-882.

Babbar, S. M., & Yong, L. C. (2023). Short term solar power forecasting using deep neural networks. Future of Information and Communication Conference,

Dissanayake, I., Wickramanayake, P., Mudunkotuwa, M., & Fernando, P. (2020). Utalk: Sri Lankan sign language converter mobile app using image processing and machine learning. 2020 2nd International Conference on Advancements in Computing (ICAC),

HUANG, Z.-J., & LAU, C.-Y. (2020). Camera Vision Foreground Detection Employing Frame Differencing And Background Subtraction In Solar Farm Monitoring Application. *Solid State Technology, 63*(1s), 883-892.

More, V., Sangamnerkar, S., Thakare, V., Mane, D., & Dolas, R. (2018). Sign language recognition using image processing. *SIGN*, *21*, 22nd.

Nath, G. G., & Arun, C. (2017). Real time sign language interpreter. 2017 IEEE International Conference on Electrical, Instrumentation and Communication Engineering (ICEICE),

Roy, P., Uddin, S. M., Rahman, M. A., Rahman, M. M., Alam, M. S., & Mahin, M. S. R. (2019). Bangla sign language conversation interpreter using image processing. 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT),

Swamy, S., Chethan, M., & Gatwadi, M. (2014). Indian sign language interpreter with android implementation. *International Journal of Computer Applications*, *97*(13).

Thea, S., Lau, C. Y., & Lai, N. (2022). Automated IoT Based Air Quality Management System Employing Sensors and Machine Learning. *Journal of Engineering Science and Technology*, *2022*, 172-184.

Vedak, O., Zavre, P., Todkar, A., & Patil, M. (2019). Sign language interpreter using image processing and machine learning. *International Research Journal of Engineering and Technology (IRJET)*, *6*, 1907-1909.

COLLABORATIVE LEARNING IN PATHOPHYSIOLOGY AND PHARMACOLOGY: A CASE STUDY OF INNOVATIVE APPROACHES IN OPEN DISTANCE NURSING EDUCATION

Supattra Changsuphan[A], Sutteeporn Moolsart[B], Premruetai Noimuenwai[C], Sansani Rattanawaraha[D], Kawit Srisamrit[E], Sukolrat Ingchatcharoen[F]

ABSTRACT

Teaching pathophysiology and pharmacology constitutes a foundational component of the Bachelor of Nursing Science program, serving as one of the initial courses that equip students with essential knowledge and practical skills for effective nursing practice. Objectives: 1) To enhance learners' knowledge and analytical thinking skills through collaborative learning activities, and 2) To increase learners' chances of successfully passing the pathophysiology and clinical pharmacology course for nurses. In this study, 18 students enrolled in the Pathophysiology and Clinical Pharmacology for Nurses course under Plan A 3 during the 1st semester of the academic year 2023. Collaborative Learning Activity Plan: 1) Administration of a pre-learning knowledge test, 2) Summarization of critical points for each unit, 3) Analysis and presentation of case studies, 4) Attendance at a lecture delivered by an expert on "Pharmacology for Nurses.", 5) Participation in knowledge-sharing and discussions, 6) Administration of a post-learning knowledge test, and 7) Evaluation of the effectiveness of the collaborative learning activities.

Results: 1) Post-test scores demonstrated a significant improvement compared to pre-test scores, 2) The pass rate among registered students was 89.50%, and 3) Students expressed the highest level of satisfaction across all aspects of the course. Conclusion: The instructional approach under Plan A3 has proven effective in fostering the development of students' analytical thinking skills, enhancing their engagement, and motivating their learning. This method facilitates active participation and continuous self-improvement. It is pivotal in their success in examinations and preparedness for advanced specialized nursing courses within the program's curriculum.

Keywords: *distance education, collaborative learning, pathophysiology, pharmacology, nursing students*

[A] *Nurse instructor and head of learning course, School of Nursing, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: supattra.cha@stou.ac.th Orcid: https://orcid.org/0000-0003-1279-4779*

[B] *Nurse instructor, School of Nursing, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: sutteeporn@yahoo.com Orcid: https://orcid.org/0009-0002-2106-0419*

[C] *Nurse instructor, School of Nursing, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: premuetairat@yahoo.com Orcid: https://orcid.org/0000-0003-2902-2898*

[D] *Nurse instructor, Faculty of Nursing Science, Assumption University, Samut Prakan, Thailand. Email: sansani23@hotmail.com Orcid: https://orcid.org/0009-0009-7637-4539*

[E] *Lecturer in Educational Technology, Office of Educational Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: witdreampaper@gmail.com Orcid: https://orcid.org/0009-0004-5574-4186*

[F] *Education statistics and research, Office of Registration, Records and Evaluation, Sukhothai Thammathirat Open University, Nonthaburi, Thailand. Email: sukolrat.ing@stou.ac.th Orcid: https://orcid.org/0000-0001-8555-0703*

INTRODUCTION

The Bachelor of Nursing Science program at Sukhothai Thammathirat Open University (STOU) follows a distance learning model, distinct from traditional nursing programs offered by closed-system universities. Most students enrolled in the program have already completed a Diploma in Public Health or a Bachelor's Degree in Public Health and are seeking to further their qualifications to become professional nurses. These students typically work full-time as public health officials and aim to upgrade their qualifications to perform nursing duties within the professional nursing context.

Teaching pathophysiology and pharmacology to nursing students is one of the foundational courses in the program, designed to build essential knowledge about how the human body functions under normal and diseased conditions. This course provides students with the fundamental understanding of human pathophysiology across various body systems and introduces the use of pharmacological therapies to treat diseases. The integration of these two areas is crucial in preparing nursing students to apply their knowledge to real-world patient care (Johnson, Johnson, & Smith, 2014).

The content of the course is divided into two parts: 1. Pathophysiology, which focuses on understanding the functioning of body systems and how they change during disease or abnormal conditions, and 2. Pharmacology, which covers the basic principles of drug therapy used in managing various diseases. Both aspects are vital for nursing students, as they provide the analytical framework and practical skills needed for diagnosing symptoms, planning initial treatments, and effectively caring for patients (Gokhale, 1995). Learning these subjects early in their academic journey lays the foundation for more advanced nursing studies, such as adult nursing, obstetrics, pediatrics, and mental health nursing, as students move into their later years of study (Slavin, 1996).

The teaching of pathophysiology and pharmacology also emphasizes the development of critical thinking and clinical decision-making skills, which are fundamental for delivering high-quality patient care. Establishing a strong knowledge base in these subjects equips students to confidently approach the more specialized nursing areas they will encounter in the future (Laal & Ghodsi, 2012).

Historically, STOU utilized Educational Plan A1, which focused primarily on final exams. However, in response to evolving educational needs, the university developed Educational Plan A2, incorporating additional teaching activities that contribute to the final grade, and Educational Plan A3, which includes both mid-term and final exams along with collaborative learning activities (STOU, 2023).

Given the complexity and depth of the content in pathophysiology and pharmacology, the Executive Committee chose Plan A3 as the most appropriate instructional approach for this course. This method encourages active student participation, content analysis, and knowledge exchange, all of which are essential for deep learning. The course's structure also enhances students' chances of passing by allocating 40% of the total grade to learning activities and dividing the remaining 60% between midterm and final exams. This approach provides students with a more continuous assessment, reducing the high-stakes pressure of a single exam (Dillenbourg, 1999).

In 2023, the course 51106 became the first course in the Bachelor of Nursing Science program to implement Plan A3. The course's teaching structure was approved by both the Executive Committee of the Bachelor of Nursing Science program and the Academic Council of Sukhothai Thammathirat Open University. The primary objectives of the course are to:

1. Enhance students' knowledge and analytical thinking skills through collaborative learning activities.

2. Improve students' chances of successfully passing the pathophysiology and clinical pharmacology course.

LITERATURE REVIEW

The shift from traditional teaching models to collaborative learning in Course 51106, Pathophysiology and Clinical Pharmacology for Nurses, reflects a growing recognition of the benefits this approach offers to students in terms of engagement, comprehension, and practical application of knowledge. Collaborative learning, defined as "the process of learning through structured group activities, interactions, and problem-solving among peers and instructors" (Johnson & Johnson, 2017), has been widely adopted in nursing education due to its effectiveness in developing critical thinking and teamwork skills.

At Sukhothai Thammathirat Open University (STOU), the original teaching model under Educational Plan A1 was highly self-directed. It relied on students completing self-study activities through teaching materials and course activities, culminating in a final exam covering all 15 units of the course. While this plan promoted independent learning, it lacked the interactive elements that are critical for complex subjects like pathophysiology and pharmacology, where collaborative learning could help deepen understanding (STOU, 2023).

Educational Plan A2 introduced supplementary teaching activities, incorporating online resources such as e-books, video clips, and both pre- and post-class assessments. These additional teaching aids, combined with some score-collecting activities, aimed to enhance the student learning experience, although the plan still primarily focused on a final comprehensive exam (STOU, 2023).

Educational Plan A3, which was adopted for Course 51106, builds on the previous models by integrating blended learning and collaborative learning activities. It includes a combination of self-study through online resources, score-collecting activities, mid-term and final exams, and structured collaborative activities such as case study analyses and group discussions. This approach provides students with the opportunity to engage in both independent study and collaborative problem-solving, making it a more effective model for courses that require the application of theoretical knowledge to real-world scenarios (STOU, 2023).

Benefits of Collaborative Learning in Nursing Education; Research consistently supports the use of collaborative learning in nursing education. According to Johnson, Johnson, and Holubec (2013), collaborative learning enhances student performance by encouraging active participation, fostering deeper understanding through peer interaction, and promoting the development of critical thinking and problem-solving skills. In a collaborative learning environment, students not only learn from their instructors but also benefit from the diverse perspectives of their peers, which can lead to better comprehension and retention of complex material (Bruffee, 1999).

In the context of Course 51106, collaborative learning activities include group discussions, case study analyses, and interactive sessions with teaching staff. These activities allow students to apply their knowledge of pathophysiology and pharmacology in a supportive and interactive environment, improving both theoretical understanding and clinical decision-making skills. This approach aligns with the findings of Gokhale (1995), who demonstrated that collaborative learning enhances critical thinking and the ability to apply knowledge in practical settings, which is essential for nursing students.

Moreover, the collaborative learning model used in Plan A3 helps to address the complexity of the course material by breaking it down into manageable units for mid-term and

final assessments. By structuring the learning process around these assessments and integrating regular collaborative activities, the course provides continuous feedback and support to students, improving their chances of success (Smith et al., 2005).

Collaborative Learning in Pathophysiology and Pharmacology; Pathophysiology and pharmacology are particularly suited to a collaborative learning approach. These subjects require students to understand not only the theoretical aspects of disease mechanisms and drug therapies but also how to apply this knowledge in real-world clinical scenarios. Collaborative learning, through activities such as group discussions and case studies, enables students to practice these skills in a safe and structured environment, where they can receive feedback from both peers and instructors (Dillenbourg, 1999).

Course 51106, with its focus on common health problems, the pathophysiology of diseases, and the pharmacological management of patients, benefits greatly from this teaching model. The use of case studies allows students to work together to analyze complex patient scenarios, while group discussions help them to articulate their understanding of drug mechanisms, side effects, and nursing care strategies (Garrison & Vaughan, 2008). This not only enhances their theoretical knowledge but also builds their confidence in clinical decision-making.

Course Aims and Learning Objectives; The overall aim of Course 51106 is to ensure that students develop a strong foundation in pathophysiology and pharmacology, with the following specific learning objectives: 1. Explain the pathophysiology of common health problems, 2. Analyze the pathophysiology of health issues and plan appropriate nursing care, 3. Describe the mechanisms of action and side effects of commonly used drugs, 4. Understand the role of nurses in the rational use of medicines, and 5. Provide effective nursing care for patients receiving common drug therapies. These objectives are reinforced through collaborative learning activities, which help students achieve a higher level of understanding by working together to solve problems and apply theoretical knowledge in clinical scenarios (Johnson & Johnson, 2017).

In conclusion, the transition to collaborative learning in Course 51106 represents a significant shift in how nursing students at STOU engage with complex subjects like pathophysiology and pharmacology. By combining self-study with structured group activities and assessments, Educational Plan A3 offers a more effective learning experience that fosters critical thinking, teamwork, and clinical decision-making. As supported by current research, collaborative learning not only enhances students' academic performance but also prepares them for the practical challenges they will face as professional nurses (Smith et al., 2005).

DATA AND METHODOLOGY

This study used a case study approach focused on the course 51106: Pathophysiology and Clinical Pharmacology for Nurses within the Bachelor of Nursing Science program at the School of Nursing, Sukhothai Thammathirat Open University (STOU). The target population consisted of 18 students enrolled in Plan A3 of this course during the first semester of the 2023 academic year.

Teaching and Learning Activities: Collaborative Learning, Plan A3. The course employed collaborative learning through two learning sessions, each lasting 6 hours per day for a total of 12 hours. These sessions were conducted on two weekends: First session: November 18-19, 2023, with 20 points awarded. Second session: January 13-14, 2024, with another 20 points awarded.

The study was designed around collaborative learning activities (Plan A3), with the 7 key components:

1. Pre-learning knowledge test: A before knowledge test was used to evaluate students' understanding before each learning session. The first test, covering Units 1-7, was administered on November 18-19, 2023, with 30 multiple-choice questions (5 choices each). The second test, covering Units 8-15, was conducted on January 13-14, 2024, also consisting of 30 questions. Both tests were provided via Microsoft Teams, and results were reported immediately to students.

2. Summarization of critical points: Students were assigned to groups of 2-3 and tasked with summarizing and presenting the main content of each unit. The first session (November 18-19, 2023) covered Units 1-7, while the second session (January 13-14, 2024) focused on Units 8-15.

3. Case study analysis and presentation: Students were divided into two groups, each analyzing two case studies: one on subdural hematoma and another on congestive heart failure. They were assigned group work to analyze the cases and present their findings. The presentations allowed for knowledge exchange among students, with discussions lasting 60 minutes.

Example questions for Case Study 1 (subdural hematoma) included:

- Assessing the patient's Glasgow Coma Scale score and its implications.
- Explaining the pathophysiology of subdural hematoma and intracranial pressure mechanisms.
- Calculating cerebral perfusion pressure pre-surgery.
- Discussing abnormal breathing mechanisms and fever post-surgery.
- Understanding fluid and mineral imbalances and how diabetes could affect the patient’s condition.

4. Expert lecture on "Pharmacology for Nurses": Delivered by Assoc. Prof. Dr. Penchom Phuengwicha, the lecture focused on drug use, covering content from Units 12-15. The lecture was recorded and posted in the course's e-learning platform for student review.

5. Knowledge-sharing and discussions: These sessions facilitated interaction between students and instructors, allowing students to share their understanding of pathophysiology and pharmacology relevant to nursing practice.

6. Post-learning knowledge test: A parallel post-test was administered after each session, identical in structure to the pre-test, to evaluate learning progress. Results were delivered to students in real-time through Microsoft Teams.

7. Evaluation of collaborative learning effectiveness: The effectiveness of collaborative learning activities was assessed using a two-pronged approach: 1) Final exam: A comprehensive exam with 120 questions, accounting for 60% of the total grade, and 2) Learning activity points: Participation in the two collaborative sessions contributed a total of 40 points (20 points each), representing 40% of the final grade.

RESULTS AND DISCUSSION

RESULTS

The results report into the quantitative and qualitative results.

First, the quantitative outcome included three parts, 1) Pre-test and post-test, 2) Final evaluation, and 3) Students’s satisfaction of the course. The details were described as followed.

First of all, pre-test and post-test scores demonstrated a significant improvement compared to pre-test scores (Table 1).

Table 1 – Pre-test and post-test scores of the 1 and 2 activities.

Seminar	Score (30)	Min (F, %)	Max (F, %)	$\bar{x}$
1	Pre-test	5 (16.67)	18 (60.00)	11.8 (39.33)
	Post-test	4 (13.34)	25 (83.34)	14.3 (47.67)
2	Pre-test	8 (26.67)	24 (80.00)	16.1 (53.67)
	Post-test	11 (36.67)	25 (83.34)	17.7 (59.00)

This table compares the pre-test and post-test scores across seminars 1 and 2, providing the minimum and maximum scores with their corresponding frequency percentages, as well as the mean for each test.

First activity: Pre-test: The minimum score was 5 (16.67%), and the maximum score was 18 (60.00%), with a mean score of 11.8 (39.33%). This indicates that before the intervention or activity, the participants performed modestly, with the majority scoring closer to the maximum. **Post-test**: After the seminar, the minimum score dropped slightly to 4 (13.34%), while the maximum increased significantly to 25 (83.34%). The mean score also improved to 14.3 (47.67%). This reflects a notable improvement in participants' performance, with a larger percentage achieving high scores after the seminar.

Second activity: Pre-test: The minimum score was higher in Seminar 2 compared to Seminar 1 at 8 (26.67%), while the maximum score reached 24 (80.00%). The mean score was also higher at 16.1 (53.67%), suggesting that the participants of Seminar 2 had a better initial understanding of the material. **Post-test**: There was further improvement in the post-test scores, with the minimum increasing to 11 (36.67%) and the maximum remaining high at 25 (83.34%). The mean score also increased to 17.7 (59.00%).

Second, the pass rate among registered students was 89.50%, The results of the educational evaluation at the end of the semester found that examination results were considered based on the total scores for all sections, consisting of scores collected from two joint learning activities, totaling 40 percent. The lowest score 15.6 points (due to participating in only 1 learning activity). Highest score 37.5 points, calculated as an average score of 31.37 points. Then, the final exam scores, 60 percents. The final exam "passed" 60 percent, 17 students, and 1 people did not take the exam due to health problems during the exam date.

Last, results of the evaluation of students' satisfaction with the joint learning activities. Online format via MS Teams system. The ersult showed the students expressed the highest level of satisfaction across all aspects of the course. Students are satisfied in teaching and learning, course 51106 Pathophysiology and clinical pharmacology for nurses, Plan A 3, was at the highest level in every aspect (Table 2 and table 3).

Table 2 - Satisfaction with the teaching and learning of course 51106 has 5 aspects.

Assessment items	$\bar{x}$	S.D	Level of satisfaction
1. Experience and learning after participating in the activity	4.50	0.69	the most
2. Opinions about speakers lecturing and conducting main activities	4.61	0.50	the most
3. Group lecturer	4.65	0.51	the most
4. Co-learning activity format	4.42	0.63	the most
5. Things to support learning	4.19	0.90	a lot
Summary	4.47	0.65	the most

Based on the data in Table 2, here is a summary of satisfaction for course 51106:

Overall Satisfaction (Mean): The overall satisfaction is represented by the summary mean score of 4.47, with a standard deviation of 0.65. This indicates a high level of satisfaction across all assessed aspects of the course. Maximum Satisfaction: The highest mean score is 4.65 for the item "Group lecturer", showing that participants were most satisfied with the group lecturer's contribution. Minimum Satisfaction: The lowest mean score is 4.19 for the item "Things to support learning", indicating this aspect had the least satisfaction, although still categorized as "a lot" of satisfaction.

Table 3 – Satisfaction with the teaching technics and student's learning outcomes of course 51106.

Assessment items	$\bar{x}$	S.D	Level of satisfactiom
Teaching technics			
1. Knowledge and the ability to convey content.	4.56	0.51	the most
2. Communication skills	4.61	0.50	the most
3. Provide an opportunity to ask questions and express opinions.	4.61	0.50	the most
4. Answer questions directly and clearly.	4.67	0.48	the most
Student's learning outcomes			
1. Knowledge increases after participating in activities.	4.50	0.71	the most
2. Apply knowledge and experience.	4.50	0.71	the most
3. Network for learning and exchanging	4.56	0.62	the most
4. Increase your own communication skills.	4.44	0.78	the most
5. Responsibility for one's own learning	4.50	0.62	the most

** Criteria for interpreting average satisfaction results, Satisfaction level: the most=4.21-5.00, a lot = 3.41-4.20, moderate = 2.61-3.40, little = 1.81-2.60, least = 1.00-1.80

Teaching Techniques: The mean scores for all items under teaching techniques indicate very high satisfaction, with all aspects rated as "the most" satisfaction. The highest score in this category is 4.67 for "Answer questions directly and clearly", showing that the ability of the instructor to provide clear and direct answers was especially appreciated. The lowest score in this category is 4.56 for "Knowledge and the ability to convey content", but even this is a very high score, reflecting the strength of the teaching approach.

Student's Learning Outcomes: The student learning outcomes also demonstrate high satisfaction, with all items scoring at "the most" level of satisfaction. The highest score in this category is 4.56 for "Network for learning and exchanging", indicating that participants found significant value in the networking and learning exchange opportunities. The lowest score in this category is 4.44 for "Increase your own communication skills", which suggests this is the area where participants felt the least improvement, though the satisfaction level remains high.

The qualitative results from student questionnaires revealed the following benefits:

- Students improved their ability to summarize key points from each unit.
- They gained experience in presenting their work and actively participating in knowledge exchange with both peers and the teaching team.
- Students developed analytical thinking skills through case study analyses and knowledge-sharing sessions, which enhanced their understanding of disease pathophysiology and how disease mechanisms affect bodily changes or abnormalities.

- They gained knowledge about the use of medications for various diseases, including diuretics, understanding drug mechanisms, side effects, and post-medication observation, follow-up, and nursing care.
- Students formed connections with both classmates and instructors.
- They enhanced their teamwork skills and demonstrated responsibility in completing assigned tasks.
- Students practiced using Microsoft Teams, improving their skills in online learning platforms.

DISCUSSION

The quantitative results of this study demonstrate significant post-test improvements in both seminars, confirming the effectiveness of the collaborative learning activities in enhancing participants' understanding of the course content. While Seminar 2 participants began with a stronger baseline knowledge, indicating they had a better initial grasp of the material, Seminar 1 participants showed the greatest improvement relative to their initial performance. This finding highlights the value of collaborative learning in bridging knowledge gaps, particularly for those with less prior exposure (Johnson, Johnson, & Smith, 2014).

Overall, satisfaction with course 51106 was exceptionally high, particularly regarding the teaching methods and learning experiences provided. The course's focus on "Joint Learning Activities" allowed students to engage deeply with the content while working collaboratively. High ratings for teaching techniques, with all items rated at "the most" level of satisfaction, reflect the effectiveness of the instructors in conveying knowledge and fostering active communication. This feedback supports previous research that emphasizes the importance of collaborative learning in creating active, student-centered learning environments (Gokhale, 1995; Laal & Ghodsi, 2012).

In terms of student learning outcomes, participants expressed high satisfaction, although the development of personal communication skills received slightly lower scores. This suggests a need for improvement in fostering these skills within the collaborative framework, though overall satisfaction remained positive. The instructors' ability to answer questions clearly was noted as a major strength, reinforcing the critical role of clear communication in the success of collaborative learning environments (Slavin, 1996).

The qualitative results further validate the successful implementation of collaborative learning strategies in course 51106. Students reported that the course encouraged active participation, peer learning, teamwork, and critical thinking. These elements are foundational to collaborative learning, which not only promotes content absorption but also facilitates knowledge sharing among peers (Bruffee, 1999). Group activities, case study analyses, and discussions were particularly effective in helping students apply theoretical knowledge to real-world situations, thereby enhancing both their understanding and practical skills.

Furthermore, the use of technology, such as Microsoft Teams, extended collaboration beyond the physical classroom and into the digital space. This aspect of the course reflects modern approaches to learning, where digital tools facilitate both synchronous and asynchronous interactions. These tools contribute to a more flexible and dynamic learning environment, supporting the growing need for hybrid learning models in higher education (Anderson, 2008).

Course 51106 is structured to integrate theory and practice, with a strong emphasis on collaborative learning activities such as group work, case study discussions, and simulations of clinical scenarios. This approach helps students develop the confidence and readiness

to manage real-world patient care situations. By incorporating midterm and final exams that are spaced appropriately to allow for content absorption, the course structure fosters deeper learning and increases the likelihood of student success. The use of accumulated points throughout the course also provides students with ongoing feedback and motivation, further enhancing their chances of passing (Dillenbourg, 1999).

However, some challenges remain, particularly concerning scheduling and enrollment limitations. Since the course is offered only in the first semester and primarily on weekends, many students—most of whom are health professionals—struggle to balance their work commitments with participation in the collaborative learning sessions. This has contributed to the relatively low enrollment in Plan A3. Additionally, second-year students who fail the course are unable to re-enroll due to scheduling conflicts with other nursing practical training and exams. Addressing these logistical issues by improving coordination with the Registration and Evaluation Office could help increase participation and improve outcomes (Smith et al., 2005).

In conclusion, the collaborative learning approach in course 51106 has proven highly effective in enhancing student engagement, knowledge retention, and practical skills. Both quantitative and qualitative assessments reinforce the value of joint learning activities in preparing nursing students for real-world clinical work. However, structural improvements, particularly in terms of scheduling and resource support, could further optimize the course's effectiveness and accessibility.

CONCLUSION

The instructional approach used in course 51106 under Plan A3 has demonstrated its effectiveness in fostering students' analytical thinking skills, enhancing engagement, and motivating continuous learning. Through collaborative learning activities, students actively participated in discussions, case studies, and practical exercises, all of which contributed to their improved performance and preparedness for real-world nursing practice. The integration of theory and practice within this instructional framework has been pivotal in students' success, both in terms of examination outcomes and readiness for more advanced, specialized nursing courses in the program.

Limitations

One limitation of the study is the small sample size, as the course was only offered to a limited number of first-year students enrolled in Plan A3 during the first semester of the 2023 academic year. Additionally, the scheduling of collaborative learning sessions on weekends posed challenges for students who are also working health professionals, limiting their participation in these critical learning activities. The course’s overlap with other nursing practical training schedules also restricted second-year students from re-enrolling after an initial failure.

Recommendations for Future Studies

Future research should explore ways to broaden the accessibility of this instructional approach by adjusting the scheduling to accommodate more students, particularly those with professional work commitments. Additionally, coordinating exam and course schedules with other nursing program activities could increase the number of students able to participate. Further studies could also evaluate the long-term impact of Plan A3's collaborative learning

model on students' performance in clinical settings and their ability to handle specialized nursing roles. Finally, expanding the sample size to include students from other academic years would provide a more comprehensive assessment of the approach's effectiveness.

REFERENCES

Anderson, T. (2008). The theory and practice of online learning. AU Press.

Bruffee, K. A. (1999). Collaborative learning: Higher education, interdependence, and the authority of knowledge. Johns Hopkins University Press.

Dillenbourg, P. (1999). Collaborative learning: Cognitive and computational approaches. Elsevier.

Garrison, D. R., & Vaughan, N. D. (2008). Blended learning in higher education: Framework, principles, and guidelines. Jossey-Bass.

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. Journal of Technology Education, 7(1), 22-30. https://doi.org/10.21061/jte.v7i1.a.2

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (2013). Cooperation in the classroom. Interaction Book Company.

Johnson, D. W., & Johnson, R. T. (2017). The impact of cooperative, competitive, and individualistic learning environments on academic achievement. Educational Psychology Review, 29(2), 149-174. https://doi.org/10.1007/s10648-017-9392-9

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. Journal on Excellence in College Teaching, 25(3-4), 85-118.

Laal, M., & Ghodsi, S. M. (2012). Benefits of collaborative learning. Procedia-Social and Behavioral Sciences, 31, 486-490. https://doi.org/10.1016/j.sbspro.2011.12.091

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. Contemporary Educational Psychology, 21*(1), 43-69. https://doi.org/10.1006/ceps.1996.0004

Slavin, R. E. (2015). Cooperative learning: Theory, research, and practice. Allyn & Bacon.

Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. Journal of Engineering Education, 94(1), 87-101. https://doi.org/10.1002/j.2168-9830.2005.tb00831.x

STOU. (2023). Announcement of Sukhothai Thammathirat Open University regarding teaching and learning criteria according to the treatment plan. For undergraduate students.

MOTIVATIONAL FACTOR OF EDUCATION ADVANCEMENT IN LIFELONG LEARNING AMONG LATE BLOOMER YOUTH IN MALAYSIA

Nor Azrul Mohd Zin[A], Analisa Hamdan[B], Nurul Farhanah Mohd Nasir[C], Sita Yiemkuntitavorn[D]

ABSTRACT

This research explores the motivational factors driving late-bloomer youth in Malaysia to pursue higher education as a component of lifelong learning. Objective: The study seeks to elucidate the underlying motivations that prompt individuals, who have postponed their academic pursuits, to re-engage with higher education later in life. Methods: A qualitative phenomenological approach was employed, utilizing in-depth interviews with twelve participants aged 25 to 40, all currently enrolled in higher education institutions. Data were analyzed through thematic analysis to extract predominant themes related to motivational factors. Results revealed that the study identifies career advancement, intrinsic motivation, and familial support as pivotal influences. Career aspirations, including the pursuit of higher qualifications for job security and salary increments, were significant motivators. Intrinsic factors such as self-fulfillment, cognitive stimulation, and the realization of personal goals were also critical. Additionally, the role of family, particularly the encouragement and support from parents and siblings, emerged as a vital component in sustaining motivation. To conclde the findings underscore the importance of recognizing and addressing these motivational factors in the development of educational policies and programs tailored to late-bloomer youth. By enhancing the support structures around these learners, educational institutions can more effectively promote lifelong learning, thereby contributing to both the personal development and professional success of this demographic. This study contributes to the broader discourse on adult education by providing insights that can inform strategies to engage and support late-bloomer learners in their pursuit of higher education.

Keywords: *Adult learner, Late bloomer, Lifelong learning, Motivational factors.*

[A] *Fakulti Sains Sosial dan Kemanusiaan (FSSK), Universiti Kebangsaan Malaysia, Selangor, Malaysia. Email: azrulzin.namz@gmail.com Orcid: https://orcid.org/0009-0002-9074-8559*

[B] *Digital Learning Hub, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: analisa@apu.edu.my Orcid: https://orcid.org/0000-0003-4225-129X*

[C] *School of General Studies, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: nurul.farhanah@apu.edu.my*

[D] *School of Educational Studies, Sukhothai Thammathirat Open University, Thailand. Email: Sita_1383@hotmail.com*

AN ENHANCED PRODUCTIVITY PREDICTION MODEL OF GARMENT EMPLOYEES USING RANDOM FOREST AND SHAP ALGORITHM

Thanarat Pattanateepapon[A], Tejtasin Phiasai[B]

ABSTRACT

Business planning through data-driven learning models to predict production outcomes can significantly reduce business risks. This approach ensures that product yields align with market demands, justifying investment and budget allocation for demand surveys, thereby enhancing business sustainability.

This research utilizes a case study of garment production to analyze various factors as variables for developing a predictive model. The model focuses on the most significant factors derived from budgeted data collection. This study proposes the integration of the Random Forest algorithm with the SHAP (SHapley Additive exPlanations) algorithm. Initially, variables are used to generate predictions with the Random Forest algorithm, followed by processing with the SHAP algorithm to identify optimized and significant input variables for productivity prediction.

Experimental results with 13 factor variables in the case study demonstrate that the proposed technique can reduce and utilize only 5 significant variables, achieving a Mean Absolute Error (MAE) difference of 2.60% compared to using the Random Forest algorithm alone. This approach effectively reduces unnecessary data collection costs.

Keywords: *Random Forest algorithm, SHAP algorithm, sustainability enhancement, production prediction*

INTRODUCTION

Regardless of the global situation, productivity remains a crucial factor for organizations as it determines business outcomes and success. Voordt (2023) examined various factors influencing productivity, including work convenience, workplace environment, and employee job satisfaction. Similarly, Lowry (2023) and Uzoamaka (2023) explored methods to predict productivity to reduce organizational costs and enhance the work atmosphere for employees. Identifying key features that significantly impact productivity allows companies to strategically plan to achieve desired outcomes, as highlighted in studies by Assaad (2023) and Ramadan (2023). Furthermore, businesses face numerous challenges, such as adapting to rapidly changing customer demands, internal and external competition, and integrating digital

[A] *B.A. (Japanese), School of science and techonology, Sukhothai thammathirat open university, Nonthaburi, Thailand. Email: 2649600109@stou.ac.th Orcid: https://orcid.org/0009-0001-7510-5961*

[B] *Ph.D. (Electrical and computer engineering), School of science and techonology, Sukhothai thammathirat open university, Nonthaburi, Thailand. Email: tejtasin.phi@stou.ac.th Orcid: https://orcid.org/0009-0007-1889-420X*

technology into business operations. Therefore, strategic business planning is essential, particularly for labor-intensive industries like apparel and food manufacturing.

According to Smith (2023), the apparel industry has determined growth. Importantly, this industry significantly influences the global financial direction due to its size and interconnectedness with various economic sectors. For instance, the apparel industry impacts the financial market, particularly for publicly traded companies. The financial performance of brands and retailers can affect stock prices and market indices. If entrepreneurs in the apparel industry can manage productivity effectively and plan their workforce in line with their productivity, utilizing modern tools to accurately predict productivity, they can enhance their competitive edge. This is because they can control production costs and achieve the planned productivity.

In the past, productivity prediction tools utilized basic statistical techniques such as averages and trend analysis, as well as advanced methods like Linear Regression (LR), as demonstrated in studies by Rathnayake (2023), Rismansyah (2023), Jones (2023), and Ariyanto (2023). Currently, machine learning is increasingly employed for prediction, accommodating more features and not limited to linear relationships. Techniques include Support Vector Machine (SVM), Random Forests (RF), k-Nearest Neighbors (kNN), and Neural Networks (NN). However, not all models can explain the significance of each feature in the prediction, complicating practical application for strategic planning and management.

This paper aims to predict garment workers' productivity in the apparel industry using machine learning and feature importance selection through SHAP (SHapley Additive exPlanations) analysis. This method helps determine the significance of each feature relative to others. The goal is to use only the necessary features and achieve results that are as good as or better than using all features.

LITERATURE REVIEW

In the past, tools for predicting productivity utilized basic statistical techniques such as averages and trend analysis, as well as advanced methods like linear regression analysis. These methods were employed in studies by Rathnayake (2023), Rismansyah (2023), Jones (2023), and Ariyanto (2023). Currently, machine learning is increasingly used for prediction, accommodating more features and not limited to linear relationships between dependent and independent variables.

Dalalah et al. (2023) developed a Support Vector Machine model to address the complex relationship between product flow and production system status, which poses challenges in assigning due dates for manufacturing. Their model helps manage these complexities by predicting production due dates and handling random order flow in multi-resource production environments. The study also highlights the significant role of service levels in negotiating due dates and understanding customer ordering trends.

Zhou (2023) developed a two-layer portfolio model using machine learning techniques to predict productivity in the garment industry, which faces significant challenges due to variability in employee performance. This model aims to bridge the gap between production targets and actual output by employing multiple regression methods, including Independent Linear Regression, Bayesian Linear Regression, Polynomial Regression, SVM Regression, Random Forest Regression, GBDT Regression, and Neural Network Regression. Tested with data from Bangladeshi garment factories, the portfolio model demonstrated superior performance with a mean absolute error (MAE) of 0.0825, compared to the standard MAE of

0.15. This improvement reduces production risks and uncertainties, enhances production efficiency, and increases profitability.

Sadatnya et al. (2023) conducted a study on accurately predicting construction crew productivity using Daily Work Reports (DWRs) through a structured three-step process: data extraction and preparation, model development, and training. The proposed framework leverages machine learning to identify key factors influencing work crew productivity, incorporating feature selection and management techniques such as handling missing values with kNN and detecting outliers. This framework is designed to assist engineers and project managers in utilizing models without requiring extensive machine learning expertise. However, challenges remain, including data quality issues and the absence of DWRs in smaller projects. Future research recommendations include standardizing DWR formats, integrating deep learning techniques, and employing new data collection methods to enhance model accuracy and efficiency.

Al I., Abdullah, and colleagues (2019) developed a Deep Neural Network (DNN) model to predict garment employee productivity using data from a major Bangladeshi clothing manufacturer. The study addresses the prevalent issue of productivity gaps in the garment industry by employing feature engineering, scaling, and encoding techniques. The model demonstrated impressive performance, achieving a mean absolute error (MAE) of 0.086, indicating reliable predictions with minimal variance from actual values.

SHAP (SHapley Additive exPlanations) analysis (Lundberg and Lee, 2017) is a powerful technique in artificial intelligence, widely used in neuroscience and machine learning. It aims to provide a comprehensive understanding of how each feature or factor influences the machine learning model. This is a key reason why SHAP analysis is advantageous for predictive models utilizing machine learning. By explaining how the machine learning model interprets data, SHAP analysis enhances transparency. This allows data scientists, researchers, and stakeholders to understand how the model predicts or diagnoses issues, facilitating informed decisions for model improvement and rational deployment. Additionally, it aids in selecting only the essential features for prediction.

Wang, Qiyan, and colleagues (2023) conducted a comprehensive study on the changes in leisure time among Beijing residents .Their findings indicate that work and housework significantly reduce leisure time. The study also highlights the impact of age and gender on leisure, revealing a U-shaped relationship between age and leisure time, with men generally having more leisure time than women. Furthermore, occupation plays a crucial role in determining leisure time, with business owners and public enterprise employees enjoying more leisure, while employees of larger companies experience less. Annual income also affects leisure time in a U-shaped manner, with both very low and very high incomes associated with reduced leisure time. The study suggests several measures to address these disparities, including reforms in holiday systems, the development of personalized leisure products using advanced technologies, and increased awareness of leisure rights.

Lee, Yong-Geon, and colleagues (2023) investigated the application of SHAP (SHapley Additive exPlanations) values to assess feature importance in short-term electrical load forecasting. The study identified limitations in traditional SHAP importance metrics and proposed a new indicator that considers the distribution of SHAP values and their relationship with the coefficient of determination. By evaluating this new metric on a 24-hour load forecasting model using XGBoost and data from the Korea Trade-Investment Promotion Agency, the researchers demonstrated that the new SHAP-based metric enhanced forecasting accuracy. The study highlights the value of the enhanced metric in explaining AI models and improving their performance.

Saranya, A., and colleagues (2023) conducted a systematic review of Explainable Artificial Intelligence (XAI) models and applications, focusing on recent developments and future trends. XAI aims to enhance the transparency, trustworthiness, and accountability of AI systems, particularly in high-stakes domains such as healthcare, finance, and security. The review encompassed literature from 2018 to 2022, analyzing 91 publications on XAI development. The study identified a research gap related to the imbalance in datasets used for research and the reliance on public datasets rather than real-world data.

This approach is supported by studies from Wang (2023), Lee (2023), and Saranya (2023), which focused on selecting influential features to improve model performance. The proposed method aims to save time in data collection and model processing while enhancing strategic planning for productivity management within the organization.

DATA AND METHODOLOGY

The dataset from Al Imran (2019) encompasses garment productivity data from January to March 2015 for a Bangladeshi garment company. It includes 13 features (department, team number, month, quarter, number of workers, number of style changes, targeted productivity, standard minute value (smv), work in progress, overtime, incentive, idle times, and idle men) and one target feature (actual productivity). The dataset includes 1,197 records. To evaluate the model's prediction performance, a random permutation technique was used in two rounds to split the data into training and testing sets, with each round consisting of 957 training records (80%) and 240 testing records (20%).

In this study, pre-collected data with 13 features was utilized, including 4 categorical features: "department", "team number", "month", and "quarter". These categorical features were encoded using One-hot Encoding to convert them into a numerical form suitable for model training. The One-hot Encoding method assigns a binary value (0 or 1) to represent the presence or absence of each category. Essentially, it creates a separate binary column for each category, resulting in either a sparse matrix or a dense array. The one-hot encoder identifies categories based on the unique values within each feature. This preprocessing step resulted in a total of 31 features for training the model.

The data analysis followed a framework for feature selection and model development to predict garment workers' productivity using SHAP and machine learning techniques. The process began with data preparation for model training. Initial models, including LR, SVM, RF, kNN, and NN, were trained. Hyperparameter tuning was then performed for each model to enhance prediction accuracy, as detailed in Table 1. Finally, the performance of the models was evaluated using Mean Absolute Error (MAE) with the testing set.

The data analysis followed a framework for feature selection and model development to predict garment workers' productivity using SHAP and machine learning techniques. SHAP is a method used to interpret the output of machine learning models. It provides a way to understand the contribution of each feature to the model's predictions by assigning each feature an importance value. This helps in identifying which features have the most significant impact on productivity predictions. The process began with data preparation for model training. Initial models, including LR, SVM, RF, kNN, and NN, were trained. Hyperparameter tuning was then performed for each model to enhance prediction accuracy, as detailed in Table 1. Finally, the performance of the models was evaluated using Mean Absolute Error (MAE) with the testing set.

Table 1 – Parameters and Values for Improving Model Prediction Performance

Model	Parameter	Value
Support Vector Machine (SVM)	C	1, 5, 10, 50, 100
	Epsilon	0.0001, 0.001, 0.01, 0.1, 1
	Kernel	Linear, RBF, Sigmoid
Random Forests (RF)	Number of trees	10, 25, 50, 100, 200, 400, 800
	Number of attributes considered at each split	3, 6, 12, 24
k-NN (kNN)	Number of neighbors	3, 5, 7, 9, 11, 13, 15
	Metric	Euclidean, Manhattan
	Weight	Uniform, Distance
Neural Network (NN)	Neuron in hidden layers	[50 : 250], [50: 250]
	Activation	Sigmoid
	Solver	SGD, Adam
	Regularization (a)	0.0001, 0.001, 0.01, 0.1, 1
	Maximal number of iterations	50, 100, 150, 250, 300, 350

Source: Prepared by the authors (2024)

RESULTS AND DISCUSSION

From the features prepared previously, we trained various models, including a traditional statistical model (LR) and machine learning models (SVM, RF, kNN, and NN). Model performance was tested using Mean Absolute Error (MAE) with the testing dataset, as shown in Table 2. The RF model produced the lowest MAE of 0.077. Consequently, this model was selected for further analysis, and feature importance was assessed using the SHAP technique.

Table 2 – Evaluation Results of Model Prediction Performance Using All Features

Model	MAE
RF	0.077
SVM	0.129
kNN	0.118
NN	0.102
LR	0.112

Source: Prepared by the authors (2024)

Based on the calculated feature importance results, the top 5 important features for the RF model were selected for retraining. These important features are targeted productivity, incentive, number of workers, standard minute value (smv), and overtime (amount of overtime for each team), as shown in Figure 1.

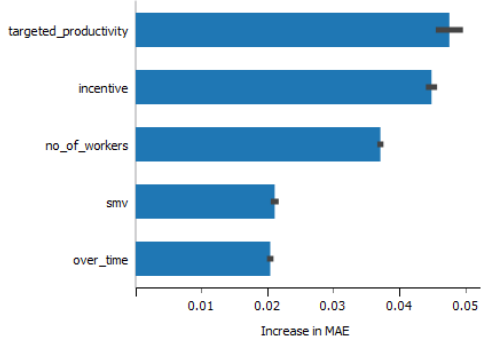


Figure 1 – Top 5 Feature Importances for RF model Using SHAP Analysis

By selecting only the top 5 most important features for the RF model, we observed a reduction in MAE from 0.077 to 0.075, which is a 2.60% decrease. The RF model with SHAP values demonstrated lower prediction errors compared to the RF model that used all features. Additionally, we conducted a detailed analysis of the impact of various features on the RF model, as shown in Figure 2, to explain the contribution of each feature. The highest contribution to predicting productivity was standard minute value, followed by incentive, number of workers, targeted productivity, and overtime, respectively. Insights from the analysis revealed that increasing the standard minute value reduces productivity. Specifically, when the standard minute value, which represents the time required to complete a task such as sewing a garment, is high, it results in longer production times per garment, thereby decreasing overall productivity. Conversely, higher incentives increase productivity. This is because substantial incentives motivate workers to increase their output in order to earn greater rewards.

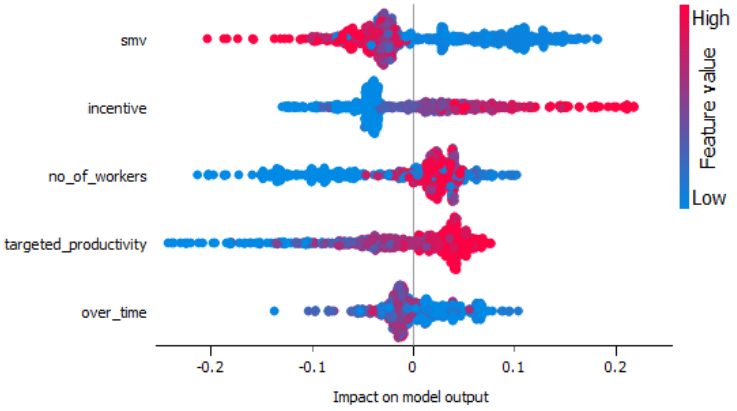


Figure 2 – Features Impact of RF-SHAP for Productivity Prediction

This case study concludes that using SHAP for feature selection effectively identifies key features, thereby enhancing the performance of the RF model. Furthermore, using only the essential features, rather than all available data, can save both time and resources in data collection. Additionally, while direct costs such as raw materials (e.g., fabrics, zipper), labor (wages and salaries), utilities (electricity, water, gas), and transportation within the production process are crucial, and indirect costs like administrative expenses also remain significant By optimizing costs can involve streamlining the focus to key productivity drivers. By prioritizing metrics such as standard minute value, number of workers, and targeted productivity, rather than tracking a broad set of minor variables, businesses can reduce operational and administrative overhead.

Table 3 – Evaluation Results of Model Prediction Performance for RF and RF-SHAP

Model	MAE
RF	0.077
RF with SHAP	0.075

Source: Prepared by the authors (2024)

CONCLUSION

The RF model with SHAP achieved a MAE difference of 2.60% compared to using the RF alone and helps explain the contribution of each feature. An increase in the standard minute value reduces the productivity, whereas a larger incentive increases productivity. These findings suggest that the developed models with appropriate features benefit the fashion and textile industries by improving resource allocation and production planning. Enhanced product forecasting can reduce costs by minimizing overtime and optimizing machinery usage.

REFERENCES

Al I., Abdullah, et al. (2019). Deep Neural Network Approach for Predicting The Productivity of Garment Employees. 6th International Conference on Control, Decision and Information Technologies (CoDIT). IEEE, 10.1109/CoDIT.2019.8820486.

Ariyanto, Ariyanto; YULIANAH, Yulianah. (2023). The Influence Of Performance Management And Compensation On The Productivity Of Hotel Employees. Jurnal Ekonomi, 12.3: 61-67.

Assaad, Rayan H., et al. (2023). Key Factors Affecting Labor Productivity in Offsite Construction Projects. Journal of Construction Engineering and Management, 149.1: 04022158.

Boland B, De Smet A, Palter R, Sanghvi A. (2020). Reimagining the office and work life after COVID-19.

Bezerra CI, de Souza Filho JC, Coutinho EF, Gama A, Ferreira AL, de Andrade GL, Feitosa CE. (2020). How human and organizational factors influence software teams productivity in covid-19 pandemic: A brazilian survey. In Proceedings of the XXXIV Brazilian Symposium on Software Engineering, pp. 606-615.

Dalalah, Doraid, et al. (2023). A support vector machine model for due date assignment in manufacturing operations. Journal of Industrial and Production Engineering, 40.1: 68-85.

Hackney A, Yung M, Somasundram KG, Nowrouzi-Kia B, Oakman J, Yazdani A. (2022). Working in the digital economy: A systematic review of the impact of work from home arrangements on personal and organizational performance and productivity. Plos one, 17(10), e0274728.

Jones, Brianna M., et al. (2023). Gender Differences in the Research Productivity of Radiation Oncology Resident Graduates in the United States: 2015 to 2019. Advances in Radiation Oncology, 8.2: 101135.

Lee, Yong-Geon, et al. (2023). Shap Value-Based Feature Importance Analysis for Short-Term Load Forecasting. Journal of Electrical Engineering & Technology, 18.1: 579-588.

Lowry, Mark Newton, et al. (2023). Impact of multiyear rate plans on power distributor productivity: Evidence from Alberta. The Electricity Journal, 36.5: 107288.

Lundberg, S. M. & Lee, S.I. (2017). Consistent feature attriution for tree ensembles. *preprint arXiv:1706.06060*. https://doi.org/10.48550/arXiv.1706.06060

Nigam, Anushree, et al. (2023). A Comparative Analysis of ML Algorithms to Improve Crop Productivity Prediction. In: 2023 International Conference on Disruptive Technologies (ICDT). IEEE, p. 154-160.

Ramadan, Mariam Ali, et al. (2023). Application of Six Sigma methodology to enhance the productivity and performance of a hotel in the UAE. The TQM Journal, 35.2: 554-576.

Rathnayake, Asitha; MURGUIA, Danny; MIDDLETON, Campbell. (2023). Analysing the impact of construction flow on productivity. In: Proceedings of the 31st Annual Conference of the International Group for Lean Construction, p. 1510-1521.

Rismansyah, SALITA S.M., VALIANTI R.M. (2023). The Effect of Performance Monitoring and Evaluation on Productivity Work of Village Devices in All District Villages. Belitang Mulya. Inovator, 12.1: 10-21.

Saranya, A.; Subhashini, R. (2023). A Systematic Review of Explainable Artificial Intelligence Models and Applications: Recent Developments and Future Trends. Decision analytics journal, 100230.

Sadatnya, Amir, et al. (2023). Machine Learning For Construction Crew Productivity Prediction Using Daily Work Reports. Automation in Construction, 152: 104891.

Smith P. (2023, 14 July). Global apparel market - statistics & facts. Statista. Retrieved from https://www.statista.com/topics/5091/apparel-market-worldwide/#editorsPicks.

Uzoamaka, Samuel, et al. (2023). Maximizing Productivity Using Spatial Organization Strategies In Rubberwood Processing Factories In Nigeria.

Voordt, Theo van der; Jensen, Per Anker. (2023). The impact of healthy workplaces on employee satisfaction, productivity and costs. Journal of Corporate Real Estate, 25.1, 29-49.

Wang, Qiyan; Jiang, Yuanyuan. (2023). Leisure Time Prediction and Influencing Factors Analysis Based on LightGBM and SHAP. Mathematics, 11.10: 2371.

Zhou, Weijie, et al. (2023) Predicting seasonal patterns of energy production: A grey seasonal trend least squares support vector machine. Expert Systems with Applications, 213: 118874.

SPATIAL ANALYSIS OF THE IMPACT OF SOCIO-ECONOMIC FACTORS ON HIGHER EDUCATION

Aurora V. Lacaste[A], Warinthorn Maneerat[B], Adirek Vajrapatkul[C]

ABSTRACT

The pursuit of higher education is a key driver of economic growth, social mobility, and innovation. Understanding the factors that influence higher education participation is crucial for developing effective policies that promote educational access and equity. This study investigates the determinants of higher education by examining a range of socio-economic factors across a global dataset. Utilizing data from the World Bank database, this research covers 195 countries in 2023 and employs ordinary least squares (OLS) and spatial regression techniques to analyze the data. The factors considered in this analysis include geographical location, GDP, gross primary education enrollment, life expectancy, minimum wage, and unemployment rate. The findings reveal that socio-economic factors exhibit significant statistical relevance in determining higher education participation. Furthermore, the analysis demonstrates that the spatial effect parameter is significant, indicating that geographical factors play a crucial role in influencing access to higher education. These insights suggest that governments, particularly in affected countries, should develop targeted policies to address socio-economic disparities and promote more equitable access to higher education.

Keywords: *Higher Education, Socio-economic Factors, Geography, Spatial Regression*

[A] *Faculty of Education, University of the Philippines Open University, Philippines; Email: aurora.lacaste@upou.edu.ph*
[B] *School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Nonthaburi,Thailand. Email: warinmanee@gmail.com*
[C] *School of Economics, Sukhothai Thammathirat Open University, Thailand. E-mail: a.vajrapatkul@gmail.com*

THE NEEDS ASSESSMENT FOR LIFELONG LEARNING OF POLICE OFFICERS

Pol.Col.Watcharapong Panittumrong[A]

ABSTRACT

The objective of this research was to analyze and prioritize needs assessment for lifelong learning of police officers. The sample group consisted of 520 officers. A questionnaire with 5 rating scales was used for data collection. The reliability of the questionnaire was 0.917. The data were analyzed by mean, standard deviation and PNI method.

The research finding were as follows. Needs assessment for lifelong learning of police officers was different. The mean of the item "what should be" was higher than "what is", in both entire and separated aspects. After the evaluation of the needs process found that; the most important need for police officers was crime prevention, technology and Innovation, language usage, police tactics and personal finance.

Keywords: *Needs Assessment, Police Officers, Lifelong Learning*

[A] *Police Education Bureau, Thailand. Email: visionwpg@hotmail.com*

IS SUSTAINABILITY MANAGEMENT ACCOUNTING SYSTEMS INEVITABLE FOR LEVERAGING INTELLECTUAL CAPITAL TOWARDS SUSTAINABLE FIRM PERFORMANCE IN DIGITAL ERA? A CROSS SECTIONAL STUDY

Marjea Jannat Mohua[A], Ong Yu Yan[B]

ABSTRACT

As the industrial economy gave way to the information-based digital economy, the corporate landscape observed substantial shifts because of globalization, financial instability, and innovations in technology. Therefore, the central construct of this paper is to bring an authentic version of how intellectual capital (IC) can enhance sustainable firm performance in the ground of sustainability management accounting systems(SMAS). A quantitative research approach was implied using the survey questionnaire method and the data were analysed through the partial least squares method (PLS). The results indicate that there is a positive affliation regarding the association between IC and sustainable firm performance. Besides, SMAS as a mediator significantly collaborate IC, resulting in enhanced economic, social, and environmental performance. In summary, the study's findings contribute to the existing literature by focusing on an aspect of how companies embrace SMAS as a fundamental strategy incorporating IC to improve sustainable firm performance. This study also provides several policies and tactics to top management of the companies and practitioners to develop a sustainability management accounting framework through firm resources and foster economic, social, and environmental performance within the demands of sustainable business landscape.

Keywords: *Sustainability management accounting systems, Intellectual capital, Sustainability, Readymade garment company, Bangladesh*

INTRODUCTION

The present market volatility prompts organizations to reconsider conventional governance approaches through innovative methods for enhancing performance (Torre et al., 2020). Hence, the concept of sustainability has greatly expanded the range of business models to incorporate a more cooperative strategy that takes into account individuals, corporate philanthropy, ecological advocacy, and responsibility (Dagiliene & Šutiene, 2019). The objective of corporate sustainability is driven not just by moral and ecological considerations but also by an obligation of conventional necessity.

According to a survey from the private sector, implementing sustainable business practices can provide economic opportunities of US $12 trillion (Harts, 1995). Nevertheless, the real-world assessment of sustainable performance has emerged as a challenging part of an

[A] *PhD, Lecturer, School of Accounting & Finance, Asia Pacific University of Technology and Innovation, Bukit Jalil, Kuala Lumpur, Malaysia. Email: marjea.jannat@apu.edu.my Orcid: https://orcid.org/0000-0001-8086-0657*

[B] *Masters in Accounting and Finance, Lecturer, School of Accounting & Finance, Asia Pacific University of Technology and Innovation, Bukit Jalil, Kuala Lumpur, Malaysia. Email: yuyan.ong@apu.edu.my*

organization's ability to thrive or develop. To achieve the objective of sustainability, companies must maintain integrity and trustworthiness concerning their influence on both environmental and societal aspects (RWE, 2022). Recently, Inayat et al. (2022) have indicated that around 60% of the worldwide ecosystem has been polluted, resulting in several types of degradation of the environment. If the issue is not adequately resolved, there will be a continuous increase in environmental problems that could eventually become difficult to control. To reduce carbon footprints, organizations must implement methods that aim at maximizing the use of energy efficiency. However, firms have encountered substantial challenges that have forced them to reevaluate and modify their strategies for achieving sustainability (Yusliza et al., 2019). The matter of concern is that organizations are still in a dilemma about how to effectively achieve sustainable firm performance (SFP), which involves economic prosperity, avoiding environmental damage, and ensuring social equity. This uncertainty arises due to the unique challenges posed by business environments that have limited resources (Yusoff et al., 2019).

Previous scholars suggested that both internal (Gunarathne et al., 2021; Tang et al., 2022), and external (Baah et al., 2021) factors play an essential role in improving the long-term viability of an organization, where knowledge assets such as intellectual capital(IC) are increasingly being recognized as crucial components of business processes and mechanisms in this digital era. However, the preceeding debate focused on multiple aspects that are ambiguous and yet unresolved in order to establish the probable linkages between IC and sustainable company performance (Gross-Gołacka et al., 2020). To be more specific, there are a plethora of studies considering the role of IC in facilitating organizational performance (Singh & Verma, 2024; Tjahjadi et al., 2024) while empirical research investigating IC influences the dimensions of sustainable performance still scarce (Gross-Gołacka et al., 2021).

In these circumstances, what is still in a dilemma is how to incorporate managerial operations where the company can transform intellectual-based resources in fostering performance. With this view, the sustainability management accounting literature proposes the effective utilization of sustainability management accounting systems (SMAS) as the sustainability balanced scorecard approach (SBSC) to expand the role of IC in enhancing economic, social, and environmental performance in the current business landscape. Specifically, the critical tactics of SBSC assist in recognizing the evolving threats and challenges that influence environmental-related strategic decisions, which creates an alignment between organizational value and goals (Fatima & Elbanna, 2023; Figge et al., 2002). Hence, identifying the preceding gaps, it's significant to examine the role of SBSC as a mediator to translate IC into SFP. Therefore, this study intends to bring further attention to the topic and provide a comprehensive overview of sustainable company performance linked with IC to success in the long run.

Unboxing the significance of IC and SMAS in the digital era:

In the trend of digitalization, traditional business procedures, and organizational performance metrics have shown a revolutionary change in the field of digital technology. These include networks, artificial intelligence, the Internet of Things (IoT), and cloud computing, which are significant forces in forcing digital transformation in the current business world. In the study, Loebbecke & Picot (2015) asserted that digitalization is now considered a way to rethink performance assessment procedures in digital settings. In this phenomenon, a novel business model is required to incorporate the new capabilities in complicated business environmental settings. Similarly, Adnan & Akbar (2019) indicated that performance measurement systems become critical when they incorporate both organized and unorganized data in the digital business environment. The trend of digital technology is dramatically

changing, and as a consequence, it's suggesting how the company can manage its operations in this phenomenon.

The rate of change caused by digital trends is drastically growing; as a result, these developments are altering how enterprises are managed. Although the practice of digital transformation is just evolving, a number of obstacles have been identified in the organizational culture, operations, and structure. However, performance management plays an important role in digital transformation while the arena of performance management remains scarce (Nudurupati et al., 2016). Researchers such as (Grover et al., 2022; Moşteanu, 2020) indicated that digital transformation requires attention to including IC in business planning and processes and organizational structure. Therefore, IC can leverage technology developments since the competences of the employees through knowledge can be efficiently distributed using digitization. By adopting and integrating the concept of digitalization and IC linking with traditional methods of instruction, companies can achieve potential benefits in order to keep up with new technologies and innovations. Hence, the contribution of this research has the opportunities to emphasize the hyperlink between people and technology in the framework of digitalization, which assists in the growth of IC.

The research is organized as follows. The second section concentrates on providing the literature on intellectual capital, sustainability management accounting systems, and sustainable firm performance. The third section delineates the methodology and the sample. Consequently, the primary findings and discussion are presented in section four. Finally, the study concludes by presenting theoretical and practical contributions as well as future directions for research.

LITERATURE REVIEW

For the purpose of investigating the affiliation between IC and SFP through the indirect effect of SMAS is relevant to the notion of "readiness" in the study settings.

Relationship between IC and sustainable firm performance:

The final phase of IC literature's emergence is relatively contemporary, whereas sustainability has been under consideration since 1972. Nevertheless, the discussion of IC and sustainability is multifaceted (Dal Mas, 2019), demanding a more rigorous investigation (Massaro et al., 2018). This phenomenon redirects concentration away from the challenge of establishing a correlation between IC and SFP. Therefore, this paper is an endeavor to elucidate the relationship between knowledge assets as IC and sustainable firm performance.

Bringing the concentration on this holistic topic, a wealth of literature has studied the relationship between IC and sustainable or organizational performance. However, substantial deficiencies remain in this particular discipline across multiple research contexts. For example, Gross-Gołacka et al. (2020) explored the correlation between IC and business sustainability, emphasizing the perspectives of managers inside SMEs in Poland. The research demonstrates that aspects of IC are vital intangible assets that generate market value for enduring competitive advantages. Findings have demonstrated that human capital is more valuable than the remaining components (relational capital and structural capital).

Nevertheless, Gross-Gołacka et al. (2021) scrutinized the same study again in different settings, and the findings revealed that the vast majority of companies in Poland neither lay nor employ IC management approaches when evaluating the connection between IC and business sustainability. Specifically, Khan et al. (2021) have clarified the notion of IC to improve

financial and environmental performance inside manufacturing SMEs in Pakistan. The study has indicated managers should take the benefit of the intellect of their workers in order to achieve greater levels of environmental performance. In another study, Muchran (2020) investigated the impact of Indonesian pharmaceutical firms utilizing IC and its three components (human capital, relational capital, and structural capital) on sustainable financial performance. The research shows a positive shadow by suggesting that intellectual resources are of paramount importance in today's business climate due to changing global financial conditions that convert industrial dynamics into knowledge-intensive engines.

On the contrary, Noor & Nawangsari (2021) found that there is a lack of notable attempts to improve the structural and relational capital of employees within the organizational structure needed for the firm's sustainability, while human capital serves as both probable and essential in the region's publicly listed companies in Jakarta, Indonesia. In the digital economy, managers face an obstacle regarding the measurement and implementation of sustainable firm performance by balancing environmental and social considerations with financial performance (Farchi et al., 2021) through the facilitation of knowledge-based resources within the business (Asiaei, Rezaee, et al., 2021). While previous literature has established a foundation for the relevance of this subject's existence, these investigations have also demonstrated conflicting findings or ambiguous notes, which leads to further investigation of the study.

The core conception of ICBV theory proposed by (Reed et al., 2006) also focuses that a company's wealth is contingent upon its individual and organizational-based resources where value is generated through the conversion of one type of capital into another, and these knowledge assets play a crucial role in increasing the market value of the organization sustainably (Malik et al., 2020; Radjenovic & Krstic, 2017). Based on the discussions mentioned earlier, the hypothesis is put forth for the present research.

H1: There is a significant relationship between intellectual capital and sustainable firm performance

Mediating role of sustainability management accounting systems in the relationship between intellectual capital and sustainable firm performance:

In order to tackle issues related to the environment, companies of any size, generations to come, and areas need to create and implement creative approaches. Such tactics are not only arbitrary but also critical and inevitable for all businesses. While management control systems particularly facilitate the integration of sustainability concepts into company operations and integrate environmental goals into businesses' missions, tactics, decisions, and mindset. In the same vein, Mio et al. (2022) also supported that the SBSC could potentially act as a beneficial tool for tackling various sustainability management requirements, especially to support organizations in performing a sustainable strategy, encouraging sustainability management practices, boost decision-making and disclosure, accomplish regulatory data commitments, comply with stakeholders' instructive needs, and enhance staff knowledge of sustainability pertains (Epstein & Buhovac, 2014; Schaltegger & Burritt, 2010).

In this vein, the relationship between strategic management accounting, environmental management systems, and organizational performance was the concentration of research conducted in Indonesia conducted by (Solovida & Latan, 2017). The study has revealed a positive affiliation among the variables by recommending that management accounting systems concentrate on environmental organizations in the assessment of sustainability management. Unexpectedly, Asiaei et al. (2021) primarily inspected the significance of performance measurement systems in the implementation of IC as knowledge-based assets for enhancing

performance. The study indicates that performance evaluation methods do not mediate the relationship between IC and corporate performance in listed Iranian companies. In the similar context, Jalil et al. (2016) performed a study in the Iranian sector to look into the impacts of strategic management accounting and environmental management systems. Organizations need to establish sustainable management accounting and operational performance (also known as reducing environmental expenses, enhancing the quality of environmental oversight, minimizing material and energy usage, and measuring the environmental consequences of processes). The present conversation highlights an essential inquiry: how can knowledge-based resources, such as intellectual capital, be valued and managed to achieve sustainable corporate performance? The mediating role of SMAS can be elucidated using the "fit as mediation" framework derived from the contingency perspective outlined by (Drazin & de Ven, 1985; Venkatraman, 1989). Based on the premises, the following hypothesis is proposed for the study:

H2: Sustainability management accounting systems mediate the relationship between intellectual capital and sustainable firm performance

DATA AND METHODOLOGY

Data collection and sample

The target population in this study was 140 LEED-based RMG companies, as certified by the U.S. Green Building Council (USGBC), prioritizing triumph achievement of sustainability disclosure and practices are selected to pursue this research (BGMEA, 2020). The rationale for selecting this industry is that textile and apparel industry in Bangladesh contributes approximately 4% to global carbon dioxide emissions, produces 70% of carbon dioxide emissions, and material manufacturing is the principal source of environmental pollution along the sector's value chain (Mahjabin, 2022). Therefore, ready-made garment companies of Bangladesh that prioritize environmental and social factors or sustainability disclosure and are registered under the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) were the final attention as the population of interest in this study.

The unit of analysis was the organization, specifically the key decision-makers, i.e., chief executive officer, chief financial officer, and deputy general manager/ general manager, who are involved in internal operations and implementation of sustainability. Top-level management plays a direct or indirect role in the establishment of sustainability practices to harmonize social and environmental factors with economic performance. With this view, a total of 280 structured questionnaires were sent to the listed sustainable-based RMG companies for data collection. Finally, out of the 280 questionnaires that were distributed, a total of 149 responses or questionnaires were valid and usable for data analysis in the next stage, with 53.21% response rates.

In the context of measurement of variables, this research selects intellectual capital as human capital (Khan et al., 2019), structural capital (Phonthanukitithaworn et al., 2023) and relational capital (Khalique et al., 2018; Khan et al., 2021) to study the sustainable firm performance presenting economic (Khan et al., 2019); social, and environmental (Malik et al., 2020; Yusoff et al., 2019) performance. Besides, sustainability management accounting systems are operationalized under the measurement of a sustainability-balanced scorecard approach (Asiaei et al., 2021; Karasneh, 2019). This study has utilized a seven-point Likert scale from "Not at all to "very great extent" for sustainable firm performance and "strongly disagree" to "strongly agree" for knowledge assets because the seven-point Likert scale is the

most accurate representation of the evaluation provided by a participant (Phonthanukitithaworn et al., 2023).

RESULTS AND DISCUSSION

After finalizing the basic characteristics of the research, PLS-SEM was utilized to establish the measurement model and the structural model to test hypotheses following the study's objective. In this study, the measurement model consists of internal consistency, reliability, and average variance extracted value (AVE), and a structural model has been established for path coefficient and indirect effects to derive innovative and conclusive findings.

Measurement Model Assessment

Within the field of research, it is conventional for the researcher to provide a rationale for the existence of measurement models, which consist of several constructs. Table 1 signifies the results of this research; IC depicts the values ranging from 0.80 to 0.90 for alpha value and composite reliability with higher reliability of 0.90 for the majority of the constructs. Consequently, convergent validity is established when the outer loadings of each item are greater than 0.70 and the average variance extracted (AVE) of each construct meets the criteria of 0.50 or above (Hair et al., 2014). Convergent validity is established by evaluating the average variance extracted (AVE) values in this study, which all exceed the threshold of 0.50, thus meeting the established criteria.

Table 1 – Cronbach's Alpha, Composite reliability and AVE

	Cronbach Alpha	Composite reliability (rho_c)	Average variance extracted (AVE)
IC	0.894	0.912	0.510
SFP	0.831	0.874	0.500
SMAS	0.915	0.928	0.501

Note: IC-Intellectual capital; SFP- Sustainable firm performance; SMAS- Sustainability management accounting systems; Source: (Prepared by the authors, 2024)

A variance inflation factor (VIF) exceeding 3.3 indicates the presence of pathological collinearity and common method bias inside a model (Kock & Lynn, 2016). According to the findings in the Table 2, it was observed that both the independent and dependent variables had values below < 3.3, thereby meeting the predetermined criterion.

Table 2 – Inner model matrix

	IC	SFP	SMAS
IC		1.467	1.000
SFP			
SMAS		1.467	

Note: IC-Intellectual capital; SFP- Sustainable firm performance; SMAS- Sustainability management accounting systems; Source: (Prepared by the authors, 2024)

The HTMT represents the mean of connections between items across different concepts, divided by the standard correlations among items assessing the identical structure (Hair et al., 2019). A standard HTMT rise should be less than 0.90, as recommended by Henseler et al. (2015), While Table 3 has revealed an acceptable value for the current study.

Table 3 – HTMT Value

	IC	SFP	SMAS
IC			
SFP	0.652		
SMAS	0.585	0.907	

Note: IC-Intellectual capital; SFP- Sustainable firm performance; SMAS- Sustainability management accounting systems; Source: (Prepared by the authors, 2024)

Structural Model Assessment

After confirming the adequacy of the measurement model, the next step in analyzing PLS-SEM results is to examine the structural model. This study employed the SMARTPLS 4.0 software to execute a bootstrap resampling procedure using 5000 resamples. Therefore, the T-value, regression weights, standard error, and multiplied correlation coefficients are all useful methods for assessing the structure of the path coefficient. The relevance of path coefficients in the model is that the hypothesized associations have a p-value of less than 0.05 (P <0.05) for statistical significance (Hair. et al., 2019). Figure 1 depicts the structural model of the study and Table 4 depicts the findings of hypotheses testing through structural model assessment.

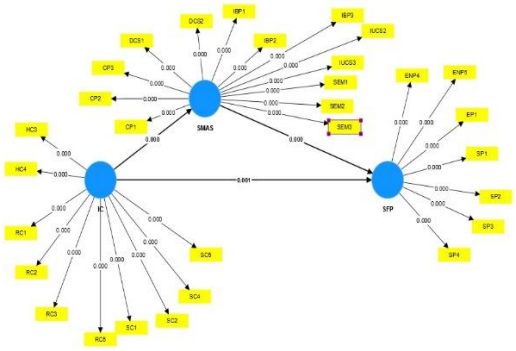


Figure 1 – Structural Model Assessment

Table 4 – Results of the Hypotheses tests

	Sample (O)	**STDEV**	**T values**	**P values**	**Decision**
IC-> SFP(H1)	0.194	0.061	3.169	0.001	Accepted
IC->SMAS-SFP(H2)	0.394	0.048	8.276	0.000	Accepted

Note: IC-Intellectual capital; SFP- Sustainable firm performance; SMAS- Sustainability management accounting systems; Source: (Prepared by the authors, 2024)

Table 4 presents the first hypothesis (H1), which proposes that there is a significant and positive relationship between IC and SFP. The path coefficient value connecting IC and SFP is 0.001, depicting a positive correlation. The t value for the connections is above the critical of 1.96, recommending at a 95% confidence level, it is considered that the path coefficient is statistically significance with a significance level of 0.05. The results support positively regarding the presence of IC for enhancing SFP ($\beta = 0.194$; T= 3.169 and P<0.05).

Second, Second hypothesis (H2) suggests that SMAS mediate the relationship between IC and SFP. The hypothesis shows a supportive and positive correlation ($\beta = 0.394$; T= 8.276 and P<0.05) with a significance level of 0.05.

CONCLUSION

This research delineates and explores the relevance of IC, such as human capital, structural capital, and relational capital, on SFP through the intervening role of SMAS. Two hypotheses were formulated based on the comprehensive review of the literature, and robust findings were derived. The study sample provided evidence that the analysis of the relationship between IC and SFP was relevant. In contrast, the influence of IC in fostering sustainable-based performance is still scarce, presenting distinct findings from the preceding literature. More specifically, this study has accomplished the objectives of this study and depicted that the IC components are inevitable in influencing the economic, social, and environmental performance through SMAS in the RMG companies of Bangladesh. Sustainability needs an integrated and holistic approach to be resilient in the dynamic economic era where the inclusion of sustainable-based managerial operations can transform intellectual resources effectively towards sustainability performance (CIMA, 2020).

Nevertheless, the subject of IC and sustainability is a comparatively still emerging area that necessitates additional scrutiny from a critical standpoint (Najib & Nawangsari, 2021). In light of these significant phenomena, this study shed light on theoretical implications. This study accumulated multifaceted views of IC to elucidate the role of SFP , presenting economic, social, and environmental performance from the vantage point of ICBV theory.

In addition to theoretical remarks, this study emphasizes the relevance of intellectual capital in the non-financial sector, specifically concerning the RMG enterprises operating in Bangladesh. Hence, this study presents a beneficial mechanism for professionals, academics, and policy-makers to examine the logical components of intellectual resources and the characteristics of sustainable company performance in RMG enterprises, which have a substantial impact on national economic strategy.

Although significant consideration is taken on IC on SFP, there is still room for improvement in the present understanding of this subject. Hence, several further research possibilities are extracted from the study's findings and limitations, and future researchers can utilize this sample for financial companies in Bangladesh or in any Asian country. Second, future researchers can utilize ICBV theory to highlight the distinct organizational resources or green-based resources necessary for the implementation of sustainable business practices. Additionally, future research can employ qualitative data collection techniques, such as conducting interviews with experts, to gain a detailed picture of the research topic at hand.

In the final analysis, this research critically poses and evaluates the question, "Is there any pathway to develop IC beyond reporting to harmonize with the social and environmental measures with economic performance from the last decade"? Researchers in the IC field can now examine non-financial factors that hold relevance for a diverse range of stakeholders, serving both internal management objectives and external transparency standards (Dumay et al., 2020). With this stream, this study has provided a layout to investigate the potential of the role of SMAS in effectively managing IC to achieve a balanced integration of economic, social, and environmental performance.

REFERENCES

Adnan, K., & Akbar, R. (2019). Limitations of information extraction methods and techniques for heterogeneous unstructured big data. *International Journal of Engineering Business Management*, *11*, 1–23. https://doi.org/10.1177/1847979019890771

Asiaei, K., Bontis, N., Barani, O., & Jusoh, R. (2021). Corporate social responsibility and sustainability performance measurement systems: implications for organizational performance. *Journal of Management Control*, *32*(1), 85–126. https://doi.org/10.1007/s00187-021-00317-4

Asiaei, K., Rezaee, Z., Bontis, N., Barani, O., & Sapiei, N. S. (2021). Knowledge assets, capabilities and performance measurement systems: a resource orchestration theory approach. *Journal of Knowledge Management*, *25*(8), 1947–1976. https://doi.org/10.1108/JKM-09-2020-0721

Baah, C., Opoku-Agyeman, D., Acquah, I. S. K., Agyabeng-Mensah, Y., Afum, E., Faibil, D., & Abdoulaye, F. A. M. (2021). Examining the correlations between stakeholder pressures, green production practices, firm reputation, environmental and financial performance: Evidence from manufacturing SMEs. *Sustainable Production and Consumption*, *27*, 100–114. https://doi.org/10.1016/j.spc.2020.10.015

BGMEA. (2020). *Sustainability Report: Go human go green*. www.bgmea.com.bd

CIMA. (2020). *Promote resiliency and sustainability with the 6 capitals*. Association of International Certified Professional Accountants. https://www.cimaglobal.com/Members/Insights/2020-CIMA-Insights/Promote-resiliency-and-sustainability-with-the-6-capitals/

Dagiliene, L., & Šutiene, K. (2019). Corporate sustainability accounting information systems: a contingency-based approach. *Sustainability Accounting, Management and Policy Journal*, *10*(2), 260–289. https://doi.org/10.1108/SAMPJ-07-2018-0200

Dal Mas, F. (2019). The relationship between intellectual capital and sustainability: An analysis of practitioner's thought. *Intellectual Capital Management as a Driver of Sustainability: Perspectives for Organizations and Society*, 11–24. https://doi.org/10.1007/978-3-319-79051-0_2

Drazin, R., & de Ven, A. H. Van. (1985). Alternative Forms of Fit in Contingency Theory. *Administrative Science Quarterly*, *30*(4), 514. https://doi.org/10.2307/2392695

Dumay, J., Guthrie, J., & Rooney, J. (2020). Being critical about intellectual capital accounting in 2020: An overview. *Critical Perspectives on Accounting*, *70*. https://doi.org/10.1016/j.cpa.2020.102185

Epstein, M. J., & Buhovac, A. R. (2014). Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts. In *Making Sustainability Work Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts*. http://www.bkconnection.com/static/Making_Sustainability_Work_2nd_EXCERPT.pdf

Farchi, C., Touzi, B., Farchi, F., & Mousrij, A. (2021). Sustainable performance assessment: A systematic literature review. *Journal of Sustainable Development of Transport and Logistics*, *6*(2), 124–142. https://doi.org/10.14254/jsdtl.2021.6-2.8

Fatima, T., & Elbanna, S. (2023). Advancing sustainable performance management in the hospitality industry: A novel framework based on a health-inclusive balanced scorecard. *Tourism Management Perspectives*, *48*(2023), 101141. https://doi.org/10.1016/j.tmp.2023.101141

Figge, F., Hahn, T., Schaltegger, S., & Wagner, M. (2002). The sustainability balanced scorecard - Linking sustainability management to business strategy. *Business Strategy and the Environment*, *11*(5), 269–284. https://doi.org/10.1002/bse.339

Gross-Gołacka, E., Kusterka-Jefmanska, M., & Jefmanski, B. (2020). Can elements of intellectual capital improve business sustainability?-The perspective of managers of smes in poland. *Sustainability (Switzerland)*, *12*(4), 1–23. https://doi.org/10.3390/su12041545

Gross-Gołacka, E., Kusterka-Jefmańska, M., Spałek, P., & Jefmański, B. (2021). Perception of intellectual capital and its impact on business sustainability: Evidence from small, medium, and large enterprises. *E a M: Ekonomie a Management*, *24*(2), 35–50. https://doi.org/10.15240/TUL/001/2021-2-003

Grover, V., Tseng, S.-L., & Pu, W. (2022). A theoretical perspective on organizational culture and digitalization. *Information and Management*, *59*(4), 103639. https://doi.org/10.1016/j.im.2022.103639

Gunarathne, A. D. N., Lee, K. H., & Hitigala Kaluarachchilage, P. K. (2021). Institutional pressures, environmental management strategy, and organizational performance: The role of environmental management accounting. *Business Strategy and the Environment*, *30*(2), 825–839. https://doi.org/10.1002/bse.2656

Hair., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, *31*(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hair, Page, M., & Brunsveld, N. (2019). Essentials of business research methods. In *Essentials of Business Research Methods*. https://doi.org/10.4324/9780429203374

Hair, Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, *26*(2), 106–121. https://doi.org/https://doi.org/10.1108/EBR-10-2013-0128

Harts, S. L. (1995). A Natural Resource View of the Firm. *Academy of Management Review*, *20*(4), 986–1014. http://www.jstor.org/stable/258963 .

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Inayat, A., Afridi, S., & Javed, A. (2022). Green Intellectual Capital and Sustainable Performance of SMEs: Roles of Green Absorptive Capacity and Green Dynamic Capabilities. *City University Research Journal*, *12*(2), 152–170. http://cusitjournals.com/index.php/CURJ

Jalil, M. H., & Abar, Mahsa Narimani Dadashian, F. (2016). Environmental Management Accounting Model on the Basis of Environmental Management System in Leather Industry. *International Journal of Environmental Science and Development*, *7*(1), 52–58. https://doi.org/10.7763/ijesd.2016.v7.740

Karasneh, A. A. F. (2019). Revitalizing the BSC through knowledge management: The mediating role of intellectual capital. *Journal of Public Affairs*, *2359*, 1–14. https://doi.org/10.1002/pa.2359

Khalique, M., Bontis, N., Bin Shaari, J. A. N., Yaacob, M. R., & Ngah, R. (2018). Intellectual capital and organisational performance in Malaysian knowledge-intensive SMEs. *International Journal of Learning and Intellectual Capital*, *15*(1), 20–36. https://doi.org/10.1504/IJLIC.2018.088345

Khan, N. U., Anwar, M., Li, S., & Khattak, M. S. (2021). Intellectual capital, financial resources, and green supply chain management as predictors of financial and environmental performance. *Environmental Science and Pollution Research*, *28*(16), 19755–19767. https://doi.org/10.1007/s11356-020-12243-4

Khan, N. U., Li, S., Khan, S. Z., & Anwar, M. (2019). Entrepreneurial orientation, intellectual capital, IT capability, and performance. *Human Systems Management*, *38*(3), 297–312. https://doi.org/10.3233/HSM-180393

Khan, S. Z., Yang, Q., & Waheed, A. (2019). Investment in intangible resources and capabilities spurs sustainable competitive advantage and firm performance. *Corporate Social Responsibility and Environmental Management*, *26*(2), 285–295. https://doi.org/10.1002/csr.1678

Kock, N., & Lynn, G. S. (2016). Lateral collinearity and misleading results in variance-based SEM: An illustration and recommendations. *Journal of the Association for Information Systems*, *13*(7), 546–580. https://doi.org/10.17705/1jais.00302

Loebbecke, C., & Picot, A. (2015). Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda. *The Journal of Strategic Information Systems*, *24*(3), 149–157. https://doi.org/10.1016/j.jsis.2015.08.002

Mahjabin, S. (2022, May 30). Why environmental sustainability is crucial for future growth of RMG exports. *The Business Standard*. https://www.tbsnews.net/thoughts/why-environmental-sustainability-crucial-future-growth-rmg-exports-429550

Malik, S., Cao, Y., Mughal, Y. H., Kundi, G. M., Mughal, M. H., & Ramayah, T. (2020). Pathways towards sustainability in organizations: Empirical evidence on the role of green human resource management practices and green intellectual capital. *Sustainability (Switzerland)*, *12*(8), 1–24. https://doi.org/10.3390/SU12083228

Massaro, M., Dumay, J., Garlatti, A., & Dal Mas, F. (2018). Practitioners' views on intellectual capital and sustainability: From a performance-based to a worth-based perspective. *Journal of Intellectual Capital*, *19*(2), 367–386. https://doi.org/10.1108/JIC-02-2017-0033

Mio, C., Costantini, A., & Panfilo, S. (2022). Performance measurement tools for sustainable business: A systematic literature review on the sustainability balanced scorecard use. *Corporate Social Responsibility and Environmental Management*, *29*(2), 367–384. https://doi.org/10.1002/csr.2206

Moşteanu, N. R. (2020). Challenges for organizational structure and design as a result of digitalization and cybersecurity. *The Business and Management Review*, *11*(01), 20–22. https://doi.org/10.24052/bmr/v11nu01/art-29

Muchran. (2020). Effect of intellectual capital on sustainable financial performance of Indonesian pharmaceutical firms with moderating role knowledge management. *Systematic Reviews in Pharmacy*, *11*(1), 203–212. https://doi.org/10.5530/srp.2020.1.27

Najib, H., & Nawangsari, L. C. (2021). Effect of Intellectual Capital on Organizational Sustainability with Employee Innovative Behavior as Intervening Variables in Pt. Jaya Maritime Services. *European Journal of Business and Management Research*, *6*(1), 158–163. https://doi.org/10.24018/ejbmr.2021.6.1.714

Noor, A., & Nawangsari, L. C. (2021). The Effect of Intellectual Capital on Organizational Sustainability through Knowledge Management on Employees of Pd Dharma Jaya in Regionally Owned Enterprises of Dki Jakarta. *European Journal of Business and Management Research*, *6*(3), 226–235. https://doi.org/10.24018/ejbmr.2021.6.3.909

Nudurupati, S. S., Tebboune, S., & Hardman, J. (2016). Contemporary performance measurement and management (PMM) in digital economies. *Production Planning & Control*, *27*(3), 226–235. https://doi.org/https://doi.org/10.1080/09537287.2015.1092611

Phonthanukitithaworn, C., Srisathan, W. A., Ketkaew, C., & Naruetharadhol, P. (2023). Sustainable Development towards Openness SME Innovation: Taking Advantage of Intellectual Capital, Sustainable Initiatives, and Open Innovation. *Sustainability (Switzerland)*, *15*(3). https://doi.org/10.3390/su15032126

Radjenovic, T., & Krstic, B. (2017). Intellectual capital in the theory of the firm. *Ekonomika*, *63*(4), 13–27. https://doi.org/10.5937/ekonomika1704013r

Reed, K. K., Lubatkin, M., & Srinivasan, N. (2006). Proposing and testing an intellectual capital-based view of the firm. *Journal of Management Studies*, *43*(4), 867–893. https://doi.org/10.1111/j.1467-6486.2006.00614.x

RWE. (2022). *Together we turn passion into sustainability*.

Schaltegger, S., & Burritt, R. L. (2010). Sustainability accounting for companies: Catchphrase or decision support for business leaders? *Journal of World Business*, *45*(4), 375–384. https://doi.org/10.1016/j.jwb.2009.08.002

Singh, B., & Verma, P. (2024). How does intellectual capital drive firm performance via dynamic capabilities: evidence from India. *International Journal of Productivity and Performance Management*, *73*(7), 2136-2155.

Solovida, G. T., & Latan, H. (2017). Linking environmental strategy to environmental performance: Mediation role of environmental management accounting. *Sustainability Accounting, Management and Policy*, *8*(5), 595–619.

Tang, Y. M., Chau, K. Y., Fatima, A., & Waqas, M. (2022). Industry 4.0 technology and circular economy practices: business management strategies for environmental sustainability. *Environmental Science and Pollution Research*, *29*(33), 49752–49769. https://doi.org/10.1007/s11356-022-19081-6

Tjahjadi, B., Soewarno, N., & Sutarsa, Annisa Ayu Putri Jermias, J. (2024). Effect of intellectual capital on organizational performance in the Indonesian SOEs and subsidiaries: roles of open innovation and organizational inertia. *Journal of Intellectual Capital*, *25*(2/3), 423–447. https://doi.org/https://doi.org/10.1108/JIC-06-2023-0140

Torre, C., Tommasetti, A., & Maione, G. (2020). Technology usage, intellectual capital, firm performance and employee satisfaction: the accountants' idea. *TQM Journal*, *33*(3), 545–567. https://doi.org/10.1108/TQM-04-2020-0070

Venkatraman, N. (1989). The Concept of Fit in Strategy Research: Toward Verbal and Statistical Correspondence. *Academy of Management Review*, *14*(3), 423–444. https://doi.org/10.5465/amr.1989.4279078

Yusliza, M. Y., Norazmi, N. A., Jabbour, C. J. C., Fernando, Y., Fawehinmi, O., & Seles, B. M. R. P. (2019). Top management commitment, corporate social responsibility and green human resource management: A Malaysian study. *Benchmarking*, *26*(6), 2051–2078. https://doi.org/10.1108/BIJ-09-2018-0283

Yusoff, R., Yusoff, H., Abd Rahman, S. A., & Darus, F. (2019). Investigating Sustainability Reporting from the Lens of Stakeholder Pressures and Isomorphism. *Journal of Asia-Pacific Business*, *20*(4), 302–321. https://doi.org/10.1080/10599231.2019.1684170

Yusoff, Y. M., Omar, M. K., Kamarul Zaman, M. D., & Samad, S. (2019). Do all elements of green intellectual capital contribute toward business sustainability? Evidence from the Malaysian context using the Partial Least Squares method. *Journal of Cleaner Production*, *234*, 626–637. https://doi.org/10.1016/j.jclepro.2019.06.153

FACTORS RELATED TO STUDENTS DROP OUT IN DISTANCE LEARNING SYSTEM IN AN OPEN UNIVERSITY IN THAILAND

Sita Yiemkuntitavorn[A], Chatchai Puttirungroj[B], Analisa Hamdan[C], Nor Azrul Mohd Zin[D], Nurul Farhanah Mohd Nasir[E]

ABSTRACT

While the demand for open and distance education is increasing after the COVID-19 pandemic, it also faces high dropout rates. This study aims to reveal the reasons for student dropouts considering the perspective of students. Data from semi-structured interviews with 15 students who decided to drop out after learning for a year in distance learning system at Master degree level of curriculum and instruction majoring English and Mathematics in an open university in Thailand. An interview guide for the semi-structured interview developed to inquire about factors related to students drop out from the university. The results revealed that students decide to drop out mainly due to four main reasons: internal reasons, external reasons, student characteristics, and student skills.

Keywords: *Drop out, Distance Learning System, Open University, Thailand*

[A] *School of Educational Studies, Sukhothai Thammathirat Open University, Thailand. Email: sita_1383@hotmail.com*
[B] *School of Educational Studies, Sukhothai Thammathirat Open University, Thailand. Email: chatchai.put@stou.ac.th*
[C] *Digital Learning Hub, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: analisa@apu.edu.my Orcid: https://orcid.org/0000-0003-4225-129X*
[D] *Fakulti Sains Sosial dan Kemanusiaan (FSSK), Universiti Kebangsaan Malaysia, Selangor, Malaysia. Email: azrulzin.namz@gmail.com Orcid: https://orcid.org/0009-0002-9074-8559*
[E] *School of General Studies, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. Email: nurul.farhanah@apu.edu.my*

INCLUSIVE ONLINE LEARNING: RECOGNIZING AND SUPPORTING AUTISTIC STUDENTS IN VIRTUAL CLASSROOMS.

Gunasegaran Karuppannan[A]

ABSTRACT

As online learning becomes increasingly prevalent, it is essential to address the diverse needs of all students, including those with autism. This research aimed to identify effective strategies for creating inclusive virtual classrooms specifically for autistic students at Open University Malaysia (OUM). A qualitative research study was conducted involving nine autistic students from OUM. The methodology included in-depth interviews and thematic analysis to explore the students' experiences and identify key strategies that enhance their learning in virtual environments. The finding identified five effective strategies for creating inclusive virtual classrooms for autistic students. ***Providing clear and concise instructions*** *using simple, direct language and avoiding idiomatic expressions can significantly reduce confusion.* ***Visual aids****, such as icons and step-by-step checklists, further enhance understanding by clarifying expectations. The study also emphasized the importance of* ***structured activities****. A defined framework with clear start and end points helps autistic students navigate tasks more effectively. Consistent steps within these activities minimize anxiety and confusion, allowing students to focus on completing their work.* ***Predictable schedules*** *emerged as another vital strategy. Sharing daily or weekly schedules in advance and maintaining consistent start and end times for classes can help students manage their time and reduce stress. Early communication of any schedule changes is essential to prevent unnecessary distress. Finally,* ***consistency in delivery*** *was found to be critical. Maintaining a consistent tone in communications, using uniform formats for assignments, and keeping the virtual classroom layout unchanged contribute to a more stable learning environment. As conclusion this research provides practical insights, offering actionable strategies to enhance inclusivity in online learning environments and better support autistic students in virtual classrooms.*

Keywords: *autistic, inclusive, online learning, virtual classroom, qualitative*

INTRODUCTION

The quick growth of online education has transformed educational access worldwide. Especially in the midst of the COVID-19 pandemic, educational establishments had to shift to remote learning, including Open University Malaysia (OUM). The move to online learning has increased flexibility, giving students the opportunity to learn at their own speed and from various regions. Despite the various benefits of online learning, it also poses specific obstacles, particularly for students diagnosed with Autism Spectrum Disorder (ASD). Autism is defined

[A] *Programme Director, Faculty of Education, Open University Malaysia. Email: gunasegaran@oum.edu.my Orcid: http://orcid.org/0000-0002-9471-7883*

by variations in social interaction, communication, and behavior, which can pose difficulties in traditional educational settings. In virtual learning settings, these challenges are frequently worsened because physical cues, sensory feedback, and structured social interactions - which some students depend on to navigate their environment - are lacking. Autistic students may find it especially challenging to navigate the online classroom if they lack proper support systems (Howlin et al., 2018).

Online courses, frequently without organization and consistency, may lead to uncertainty, annoyance, and stress for these learners. Furthermore, an important obstacle to supporting autistic students in online learning settings is that many instructors are unaware of the possibility of having autistic students in their classes. In contrast to traditional classrooms where certain behaviors or learning difficulties are easier to notice, online environments may conceal these traits, causing educators to be unaware of the varied learning requirements of their students. Many instructors teach their online courses as if all students are the same, without recognizing the diversity present in their classroom.

Many lecturers not only lack awareness but also have limited understanding about autism and how to support the unique learning needs of autistic students. Not being informed can result in teaching methods that unintentionally isolate or overpower these students. For example, unclear directions, conflicting messaging, and disorganized tasks can worsen the challenges that autistic students encounter in online learning settings (Smith, 2019). This lack of comprehension can greatly impact autistic students, who typically depend on structured environments, clear instructions, and predictable routines to excel academically.

Lacking these crucial supports, autistic students could face increased anxiety, lack of involvement, and poor performance in their online classes. This problem is made more complex by the fact that a lot of online courses are asynchronous, which means autistic students may not receive the immediate feedback and interaction they require to understand instructions or complete assignments. Hence, it is essential for organizations such as OUM to not just acknowledge the existence of autistic students in their online classes but also implement inclusive teaching methods to meet their individual requirements. OUM can establish a fairer and more inclusive learning environment by educating lecturers and equipping them with the proper training to identify and assist autistic students. Implementing inclusive tactics, like simplifying communication, providing visual aids, and keeping consistent class structures, can alleviate obstacles for autistic students and enhance their educational experience in online environments.

PROBLEM STATEMENT

The move to online learning has presented educational institutions with fresh obstacles, especially in meeting the needs of various student groups. Autistic students frequently face more challenges in online settings because of the absence of clear organization, non-verbal cues, and unexpected elements that can be present in virtual courses. Although traditional classroom environments can be adjusted to accommodate autistic students with organized schedules, simplified communication, and sensory modifications, applying these tactics to an online platform is not always simple (Smith, 2019).

In Open University Malaysia (OUM), autistic students encounter distinctive challenges that are frequently disregarded, especially in the presence of the essential online learning platform. Studies show that the absence of personalized assistance in digital platforms can result in increased stress and disinterest in autistic students (Soto et al., 2020). For example,

ambiguous directions, conflicting course structures, abrupt schedule modifications, and lack of visual support can all lead to increased confusion and stress.

Additionally, numerous educators and institutions lack knowledge about the particular adjustments needed by autistic students in virtual classrooms, resulting in a uniform approach to designing online courses. This lack of comprehension and application can result in autistic students not getting the needed assistance to thrive in their academic studies. Hence, there is an urgent requirement to investigate and pinpoint the tactics that can be utilized to establish a more welcoming online learning setting for autistic students at OUM. This research aims to address the lack by studying the main obstacles that autistic students encounter in online learning and suggesting practical solutions to overcome them.

RESEARCH OBJECTIVES

This study aims to address the gap in understanding how virtual classrooms can better accommodate autistic students by identifying specific strategies that can enhance their learning experiences at OUM. The key objectives of this study are:

1. To explore the challenges faced by autistic students in virtual classrooms.
2. To identify effective strategies that enhance their understanding, participation, and overall learning experience.
3. To provide recommendations for improving inclusivity in virtual learning environments, with a focus on the specific needs of autistic students.

LITERATURE REVIEW

Autism and Education

Autism Spectrum Disorder (ASD) affects about 1 in 54 children in the United States and is becoming more common worldwide (Centers for Disease Control and Prevention, 2020). ASD is identified by ongoing issues in social communication, limited interests, and repetitive actions, which may result in struggles in school with understanding directions, adjusting to changes, or handling sensory stimuli (Volkmar et al., 2018). These characteristics frequently lead to an educational experience that is not just distinct but also more demanding in comparison to neurotypical students.

Autistic students might find it challenging to grasp abstract ideas, unclear communication, and tasks without clear instructions (Howlin et al., 2018). In the traditional classroom, teachers have always used different methods to help meet the learning requirements of autistic students. The usual strategies involve setting clear, consistent expectations, making visual schedules, using simple language, and establishing structured routines to lower anxiety and improve focus (Williams & Hanke, 2007). Studies show that structured settings benefit autistic students by reducing uncertainties and offering a predictable learning experience, leading to improved outcomes (Parsons et al., 2011).

Nevertheless, the transition of these resources to online education has been difficult. Many autistic students rely on tangible cues, social interactions, and structured feedback mechanisms which are often missing in virtual learning environments. For all students to thrive in a classroom, it is important to acknowledge and provide accommodations for the diverse needs of neurodiverse learners, including individuals with autism (Ashburner et al., 2020). In a

traditional classroom, teachers can easily notice a student's actions and make changes as needed, but in online classrooms, making immediate adjustments can be challenging.

Inclusive Online Learning

The way educational institutions deliver their curricula has been changed by the increased use of online education, especially during the COVID-19 pandemic. Open University Malaysia (OUM) and other institutions globally have embraced virtual classrooms to maintain the delivery of education, taking advantage of the convenience provided by online platforms (Rasmitadila et al., 2020). Nevertheless, even though virtual learning environments offer advantages in terms of flexibility and accessibility, they also present new difficulties, especially for students with Autism Spectrum Disorder (ASD).

An important issue in online education is that the majority of digital learning platforms were not initially created with neurodiverse students in consideration. A research conducted by Soto et al. (2020) discovered that numerous platforms heavily depend on text-based communication, causing challenges for students with language processing issues or difficulties with abstract reasoning. Furthermore, asynchronous learning methods, requiring students to work independently with limited real-time support, can lead to anxiety for autistic students who rely on instant clarification or support (Soto et al., 2020).

Visual learning tools and real-life examples are often helpful for autistic students, but these are occasionally lacking in online classes. Visual learners may find it challenging in settings where instructions are primarily given through speaking or written words. Autistic students may have difficulty understanding concepts, following instructions, or engaging in group activities because they do not have access to visual and social cues from instructors in real-time (Koegel et al., 2014). Moreover, a large number of teachers may not realize that they are instructing students with autism in their online classrooms. In contrast to traditional environments, online platforms may hide autistic behaviors, causing instructors to believe their students are all similar (Scott et al., 2017). Consequently, teachers may not make any changes or modifications to support the needs of autistic students during instruction.

Strategies for Inclusivity

There is an increasing acknowledgment of the significance of embracing inclusive strategies in online education to assist neurodiverse students, such as those with autism. The literature highlights various methods to enhance the inclusivity of online learning platforms, making sure they can cater to a wider array of students. The use of straightforward and concise language in instructions is a crucial strategy. Unclear or overly complicated directions can cause confusion for students with autism, who may already have difficulty with understanding language (Smith, 2019). Offering clear, straightforward guidance, dividing tasks into smaller, achievable increments, and steering clear of idiomatic expressions can assist in minimizing confusion and anxiety (Ashburner et al., 2020).

The utilization of visual aids, along with effective communication, is emphasized as crucial for assisting autistic students in virtual classrooms. Studies have indicated that visual aids like icons, diagrams, and step-by-step lists can assist in outlining expectations and offering organization, thus aiding autistic students in staying concentrated and following instructions (Parsons et al., 2011).

Visual aids play a crucial role in online learning settings, where there is a lack of traditional classroom settings and schedules. Having structured activities with clear beginnings and endings is also an essential aspect of an inclusive online classroom. Autistic students benefit

greatly from predictability and routine, as unstructured or unpredictable environments can intensify their anxiety. Educators can assist autistic students in effectively managing their time and alleviating uncertainty by offering a well-defined structure for each task (Koegel et al., 2014). Breaking assignments into smaller tasks with clear goals helps students by allowing them to concentrate on individual steps, which in turn reduces the mental strain of handling a big, ambiguous project.

In addition, it's important to keep a regular routine and avoid sudden changes to help decrease stress in students with autism. Giving early notification of any modifications to the schedule, like adjustments to class times or due dates, enables students to plan ahead and adapt their schedules accordingly (Miller, 2021). Maintaining consistency in presenting course material, such as utilizing a standardized assignment format and keeping the virtual classroom layout consistent, promotes a steady learning atmosphere, decreasing the chance of confusion or irritation. Ultimately, the idea of "universal design for learning" (UDL) has become more recognized as a model for establishing more inclusive educational environments.

UDL principles support the idea of offering various ways for presenting information, demonstrating understanding, and keeping learners engaged to accommodate a variety of student needs (CAST, 2018). UDL strategies for autistic students may consist of providing alternative communication methods, such as visuals instead of verbal instructions, offering flexible assessment options like allowing students to demonstrate their knowledge in various formats, and providing multiple ways to interact with the course material (Ashburner et al., 2020). By integrating UDL principles into online classes, teachers can more effectively cater to the varied learning requirements of their students, including individuals with autism.

METHODOLOGY

Research Design

This study utilized a qualitative research approach, which is well-suited to exploring the subjective experiences of autistic students in virtual classrooms. A case study design was selected, focusing on the experiences of nine autistic students at Open University Malaysia (OUM). The qualitative approach allowed for in-depth exploration of participants' personal experiences, challenges, and strategies that worked for them.

Participants

The participants in this study were nine autistic students enrolled in various online courses at Open University Malaysia (OUM). Out of the nine participants, seven were undergraduate students, while two were postgraduate students. All participants were male, and the information regarding their enrollment and diagnosis was gathered from OUM's admission office. This office confirmed that each participant had a formal diagnosis of Autism Spectrum Disorder (ASD) and was actively engaged in OUM's online learning system.

OUM primarily caters to working adults, and these participants were no exception. All the students in this study were employed and pursuing their degrees part-time, balancing both their professional and academic responsibilities. This characteristic is significant because it adds an additional layer of complexity to their experiences, as they navigate not only the challenges of being autistic students in a virtual classroom but also the demands of their professional lives.

The participants were geographically diverse, hailing from different parts of Malaysia, which reflects the nationwide reach of OUM's flexible, online learning model. This geographical dispersion may also influence their experiences with online learning, as they are exposed to varying levels of access to resources such as internet connectivity and technological infrastructure.

For confidentiality purposes, the participants are referred to as Participant 1 (P1) through Participant 9 (P9). This naming convention ensures the protection of their identities while allowing for the presentation of individual experiences in the study. All participants provided informed consent to participate in this research, understanding that their responses would contribute to identifying strategies for creating more inclusive online learning environments for autistic students at OUM.

Data Collection

Data for this study were collected through semi-structured, in-depth interviews conducted via Google Meet. Prior to scheduling the interviews, each participant was contacted through email to obtain their permission to participate in the study. The email also included detailed information about the study's purpose, confidentiality, and the structure of the interviews, allowing the participants to make an informed decision about their involvement. Once the participants agreed to take part in the study, they were given the flexibility to choose a convenient date and time for their Google Meet session, ensuring that the interview scheduling did not interfere with their professional or academic commitments. The interviews, which lasted between 20 to 30 minutes, were designed to explore the participants' experiences with navigating virtual classrooms, the challenges they encountered as autistic students in an online learning environment, and the strategies they found most helpful in their educational journey. All participants were asked the same structured questions to maintain consistency in data collection, ensuring that each individual's responses could be compared and analyzed effectively. The questions were carefully crafted to elicit detailed insights into the participants' interactions with OUM's virtual learning platform, as well as their preferences for instructional strategies and classroom organization.

The flexibility in scheduling, along with the use of Google Meet, allowed the participants to conduct the interviews from the comfort of their own homes or workplaces, thereby reducing potential stress or discomfort. Each interview was recorded with the participants' explicit consent, and the recordings were later transcribed for analysis. The structured questions provided a framework for the interviews, but participants were encouraged to elaborate on their responses and discuss any additional experiences they felt were relevant. This approach allowed for both depth and consistency in the data, capturing a comprehensive picture of the students' experiences in virtual classrooms at OUM.
The interview questions are as in Appendix 1.

Data Analysis

Thematic analysis was used to analyze the data, following the six-step process outlined by Braun and Clarke (2006). After transcribing the interviews, the data were coded manually. Initial codes were generated based on recurring ideas and patterns in the responses. These codes were then categorized into broader themes that aligned with the research objectives. The themes were refined through multiple rounds of review to ensure they accurately reflected the participants' experiences.

The analysis of the interview data was conducted using a thematic analysis approach, which allowed for the identification and organization of recurring themes across participants' responses. The analysis was guided by the interview questions, which were designed to explore five key themes: Clear and Concise Instructions, Use of Visual Aids, Structured Activities with Predictable Outcomes, Predictable Schedules, and Consistency in Communication and Delivery.

Step 1: Familiarization with the Data

The first step in the analysis involved a thorough review of the interview transcripts. Each interview was carefully transcribed and read multiple times to ensure deep understanding of the content. Special attention was given to the interviewees' experiences and suggestions related to each theme.

Step 2: Initial Coding

Once familiar with the data, initial coding was performed. Responses were broken down into smaller, meaningful units, with specific emphasis on key phrases and detailed statements related to each of the five themes. For example, responses that provided insight into the clarity of instructions, the usefulness of visual aids, or the predictability of schedules were highlighted.

Step 3: Identifying Patterns and Categories

After the initial coding, the codes were grouped into broader categories, aligned with the five pre-determined themes. For **Theme 1: Clear and Concise Instructions**, codes were created around participants' descriptions of clarity, confusion, and suggestions for improvement. In **Theme 2: Use of Visual Aids**, the focus was on how visual aids facilitated understanding and whether participants preferred visuals over text-only materials. Similarly, responses to **Theme 3: Structured Activities with Predictable Outcomes**, **Theme 4: Predictable Schedules**, and **Theme 5: Consistency in Communication and Delivery** were categorized by how students responded to these aspects of their online learning experiences.

Step 4: Reviewing and Refining Themes

The identified themes were reviewed and refined to ensure they accurately reflected the interview data. The responses were cross-checked to confirm that each theme captured the essence of the participants' experiences. During this process, patterns and commonalities across participants were noted, such as common frustrations with unclear instructions or positive experiences with the use of diagrams or charts to explain complex ideas.

Step 5: Integration of Verbatim Quotes

Verbatim quotes were selected to support the discussion of each theme, providing evidence and enhancing the credibility of the findings. For instance, participants frequently shared their challenges with unclear instructions, such as:

"Sometimes the instructions are too vague, and I'm left guessing what the lecturer expects. There was one task where I had to email the lecturer for clarification, and it delayed my work by a few days. If they could be more specific, it would save a lot of time." (Participant 4)

For **Theme 2: Use of Visual Aids**, one participant reflected on how visuals improved understanding:

"I remember one class where the lecturer used a flowchart to explain a process, and it clicked instantly. Without that visual aid, I probably would have spent more time trying to figure it out just from reading the text." (Participant 2)

Such quotes were chosen to ensure that the findings were grounded in the participants' own words, reflecting their genuine experiences.

Step 6: Interpretation and Discussion

Finally, the themes were analyzed in relation to the broader context of online education, focusing on how these factors—clarity, visual aids, structured tasks, predictable schedules, and consistency—impact student learning and engagement. The analysis highlighted areas where improvements could be made, based on the suggestions from participants. For example, many students requested clearer, step-by-step instructions for assignments and preferred consistency in communication across different modules. Through this systematic analysis, the study was able to identify key strategies that contribute to the creation of inclusive virtual learning environments for autistic students. By ensuring that each theme was deeply rooted in the participants' experiences, the study provides practical insights into how educators can improve the online learning experience for neurodiverse students.

FINDINGS

The thematic analysis of the interviews revealed five key themes that significantly impact the online learning experience of autistic students: Clear and Concise Instructions, Use of Visual Aids, Structured Activities with Predictable Outcomes, Predictable Schedules, and Consistency in Communication and Delivery. Each of these themes highlights specific areas where improvements can be made to create a more inclusive and supportive learning environment.

Theme 1: Clear and Concise Instructions

A recurring concern among participants was the need for clear and concise instructions. Many of the students expressed that ambiguous or overly complex instructions led to confusion and anxiety. For instance, Participant 1 shared, *"When the instructions are too wordy, I get lost. It's easier when the language is simple and to the point."* All nine participants agreed that straightforward, step-by-step instructions improved their ability to follow and complete tasks in online courses. The findings suggest that autistic students benefit from precise and direct communication, avoiding idiomatic language or unnecessary complexity, which is consistent with the findings of Soto et al. (2020). This clarity allows them to focus more on completing tasks rather than deciphering what is being asked of them, contributing to their overall academic success.

Theme 2: Use of Visual Aids

The second theme that emerged from the data was the positive impact of visual aids on students' understanding of course material. Participants frequently mentioned that the use of diagrams, charts, and other visual supports helped them grasp complex concepts more effectively. Participant 5 noted, *"When there's a visual, like a checklist or diagram, I understand what to do better. It makes things clear."* Many students felt that visual aids not only enhanced their comprehension but also reduced cognitive overload, a critical concern for

autistic learners. The literature supports these findings, with research by Volkmar et al. (2018) indicating that visual aids allow students to break down tasks into manageable parts, easing cognitive load. In this study, visual aids were highlighted as a key resource for improving engagement and understanding, especially in content-heavy courses.

Theme 3: Structured Activities with Predictable Outcomes

Participants expressed a strong preference for structured activities with clearly defined steps and outcomes. The anxiety associated with open-ended or loosely structured tasks was a consistent theme. Participant 7 stated, *"I like knowing exactly what steps I need to follow. When there's a clear structure, I don't feel anxious."* This sentiment reflects the broader challenge autistic students face when tasks are left too open to interpretation. Structured environments provide a sense of control and predictability, which helps students manage their time and stay focused. Smith (2019) supports this finding, arguing that structured tasks lead to greater success for autistic students by reducing their anxiety and promoting concentration. Participants in the study confirmed that well-defined, step-by-step assignments helped them stay on track and reduced feelings of uncertainty.

Theme 4: Predictable Schedules

Predictability in class schedules and deadlines was another significant factor influencing the students' experiences. The unpredictability of sudden schedule changes caused considerable distress among participants. Participant 9 explained, *"I need to know in advance if the class time is changing. Otherwise, it throws me off."* All nine participants emphasized the importance of receiving the class schedule at the beginning of the semester, with minimal last-minute changes. This finding is consistent with Miller (2021), who highlights the importance of routine for autistic students. Disruptions in schedule can lead to heightened anxiety and negatively impact students' ability to participate fully in online courses. The participants recommended that lecturers communicate any adjustments well in advance to avoid unnecessary stress and allow students to plan accordingly.

Theme 5: Consistency in Communication and Delivery

Finally, consistency in both communication and course delivery was found to be critical for reducing cognitive load and helping students manage their workload. Participant 2 highlighted this point, saying, *"When everything is always in the same place, I know where to find it. I don't get overwhelmed."* Consistency in the format of assignments, the layout of the virtual classroom, and the communication methods used by lecturers were all identified as important factors that helped students navigate their learning environment more easily. Inconsistent formats or unclear communication created confusion and frustration. By maintaining uniformity in course materials, lecturers can provide a more stable and predictable learning environment, which in turn reduces students' cognitive load and allows them to focus on learning rather than logistical concerns.

CONCLUSION

This research provides valuable insights into the unique challenges faced by autistic students in virtual classrooms and offers practical strategies to foster inclusivity. Through the

experiences of nine autistic students at Open University Malaysia (OUM), the study highlights the critical role of clear communication, structured activities, visual aids, predictable schedules, and consistent delivery in enhancing the online learning experience for neurodiverse students.

The findings reveal that autistic students often struggle with ambiguity and inconsistency in virtual environments, which can lead to confusion, anxiety, and disengagement. By addressing these challenges with tailored strategies—such as simplifying instructions, integrating visual supports, and maintaining predictable routines—educators can create a more accessible and supportive online learning environment. The study also emphasizes the importance of early communication regarding any changes to class schedules or course structures, which can significantly reduce stress and improve students' ability to manage their time effectively.

In conclusion, this research demonstrates that inclusivity in virtual classrooms is not only achievable but essential for the success of autistic students. By adopting the strategies identified in this study, educators and institutions like OUM can ensure that online learning environments are designed to meet the diverse needs of all students. These actionable recommendations contribute to the growing body of knowledge on autism in education and offer a roadmap for creating more equitable and inclusive online learning spaces in the future. Implementing these practices can lead to better academic outcomes, increased engagement, and a more positive learning experience for autistic students, ultimately supporting their success in higher education.

REFERENCES

Ashburner, J., Vickerstaff, S., & Parsons, R. (2020). Online learning for autistic students: What educators should know. *Journal of Autism and Developmental Disorders, 50*(2), 312-329. https://doi.org/10.1007/s10803-019-04378-4

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

CAST. (2018). *Universal design for learning guidelines version 2.2*. http://udlguidelines.cast.org

Centers for Disease Control and Prevention. (2020). Data and statistics on autism spectrum disorder. https://www.cdc.gov/ncbddd/autism/data.html

Howlin, P., Magiati, I., & Charman, T. (2018). Autism spectrum disorder: Developmental psychopathology from infancy through adolescence. *Annual Review of Clinical Psychology, 10*, 363–389. https://doi.org/10.1146/annurev-clinpsy-032813-153710

Koegel, L. K., Matos-Freden, R., Lang, R., & Koegel, R. L. (2014). Interventions for children with autism spectrum disorders in inclusive school settings. *Cognitive and Behavioral Practice, 21*(2), 167-178. https://doi.org/10.1016/j.cbpra.2013.08.003

Miller, M. (2021). Supporting neurodiverse learners in online education: Strategies for success. *Journal of Educational Technology Research, 64*(3), 12–29. https://doi.org/10.1007/s11423-021-09956-8

Parsons, S., Yuill, N., Good, J., & Baldaro, B. (2011). Designing inclusive educational software for students with autism. *International Journal of Educational Technology*, 15(1), 101-113. https://doi.org/10.1111/j.1365-2729.2010.00367.x

Rasmitadila, R., et al. (2020). The perceptions of primary school teachers of online learning during the COVID-19 pandemic period: A case study in Indonesia. *Journal of Ethnic and Cultural Studies, 7*(2), 90-109. https://doi.org/10.29333/ejecs/388

Smith, J. (2019). Designing inclusive online courses: Practical strategies for neurodiverse students. *Higher Education and Disability Studies, 45*(2), 189–205. https://doi.org/10.1080/1034912X.2019.1631910

Soto, G., Clarke, M. T., & Nelson, K. (2020). Autistic students in higher education: Barriers and facilitators of success in online learning environments. *Journal of Autism and Developmental Disorders, 50*(4), 1242–1255. https://doi.org/10.1007/s10803-019-04305-7

Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Klin, A. (2018). Autism and the pervasive developmental disorders. *Cambridge University Press*. https://doi.org/10.1017/CBO9780511573059

APPENDIX

Interview Questions

Theme 1: Clear and Concise Instructions

1. How do you typically feel when you receive instructions for assignments or tasks in your online courses? Are they usually clear and easy to follow?
2. Can you describe a situation where you found the instructions in an online class confusing or unclear? How did this impact your ability to complete the task?
3. What would you suggest to lecturers to make their instructions more understandable for you?

Theme 2: Use of Visual Aids

1. Do you find it helpful when lecturers use visual aids like icons, charts, or diagrams to explain concepts? Can you give an example of a time when a visual aid helped you understand something better?
2. How do you feel about assignments or lessons that only rely on text or verbal instructions? Do you think adding visuals would help, and if so, how?
3. What types of visual aids do you think should be used more frequently in online classes to improve your learning experience?

Theme 3: Structured Activities with Predictable Outcomes

1. Do you prefer tasks that have clear start and end points? How does having a structured activity affect your ability to complete tasks on time?
2. Can you share a time when an unstructured or open-ended task in an online class made you feel confused or anxious? How did you handle that situation?
3. What kind of structure do you think works best for you when working on assignments or projects in online classes?

Theme 4: Predictable Schedules

1. How important is it for you to know the class schedule and deadlines well in advance? How do you feel when there are last-minute changes to the schedule?
2. Have you ever experienced unexpected changes in class schedules or deadlines that caused you stress? How did you manage the situation?
3. What recommendations would you give to lecturers regarding scheduling and deadline communication to help reduce any anxiety or stress?

Theme 5: Consistency in Communication and Delivery

1. Do you find it helpful when the format of assignments and the layout of the virtual classroom remain consistent throughout the course? How does consistency affect your learning?
2. Can you describe a time when inconsistent communication from a lecturer (such as varying formats of instructions) caused confusion or difficulty in completing your work?
3. What specific suggestions do you have for maintaining consistency in the virtual classroom to make the learning process easier for you?

Conference Secretariat

Sukhothai Thammathriat Open University
9/9 Mu 9, Chaengwattana Rd.
Bangpood, Pakkret, Nonthaburi
11120 THAILAND

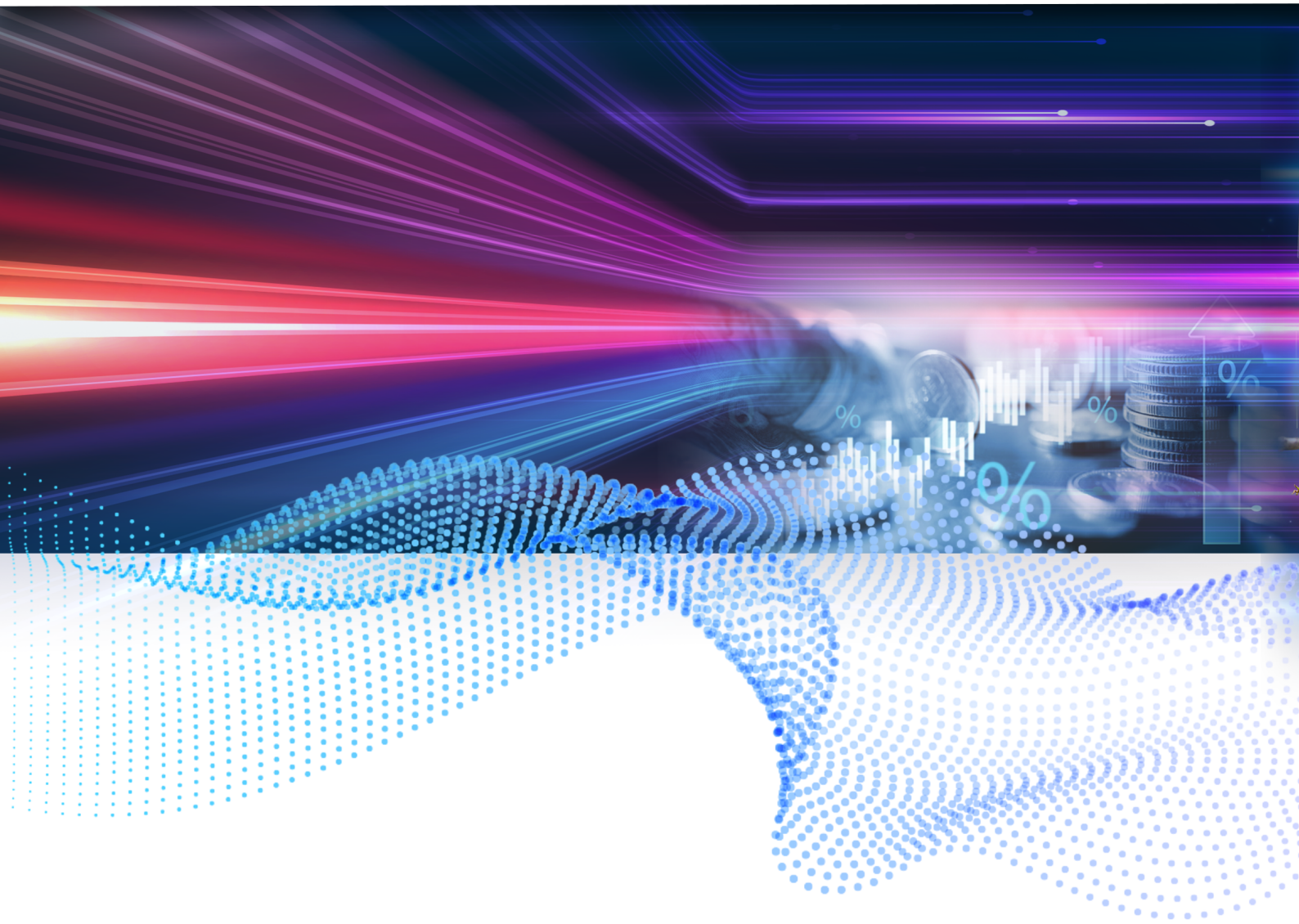
Office: +66 2 504 7171 up to 7175

e-mail: icdbse2024@stou.ac.th

ICDBSE

A·P·U
ASIA PACIFIC UNIVERSITY
OF TECHNOLOGY & INNOVATION

46th STOU Anniversary



Partners

ASIAN ASSOCIATION OF OPEN UNIVERSITIES

INTERNATIONAL COUNCIL FOR OPEN AND DISTANCE EDUCATION

Southeast Asian Ministers of Education Organization

CHITKARA UNIVERSITY

OUM OPEN UNIVERSITY MALAYSIA

OPEN UNIVERSITY

UNIVERSITAS TERBUKA