สมาคมสถาบันอุดมศึกษาเอกชนแห่งประเทศไทยในพระราชูปถัมภ์สมเด็จพระเทพรัตนราชสุดาฯ สยามบรมราชกุมารี (สสอท.)
สมาคมเทคโนโลยีและสื่อสารการศึกษาแห่งประเทศไทย (Thai AECT) และ NCAR NBU ร่วมมือกับเครือข่ายเบญจมิตรวิชาการ

การประชุมวิชาการระดับชาติและนานาชาติ เบญจมิตรวิชาการ ครั้งที่ 16

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จัดทำโดย สำนักวิจัย และบัณฑิตวิทยาลัย มหาวิทยาลัยนอร์ทกรุงเทพ

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16	ผู้ช่วยศาสตราจารย์ ดร.ญาณวัฒน์	พลอยเทศ	มหาวิทยาลัยเซาธ์อีสท์บางกอก

ด้านสังคมศาสตร์และสหวิทยาการ (ต่อ)

ลำดับ	ชื่อ-นามสกุล		สถาบัน
17	ผู้ช่วยศาสตราจารย์ ดร.นัทธีรา	พุมมาพันธุ์	มหาวิทยาลัยเซาธ์อีสท์บางกอก
18	ผู้ช่วยศาสตราจารย์ ดร.นิยม	กริ่มใจ	มหาวิทยาลัยเซาธ์อีสท์บางกอก
19	ผู้ช่วยศาสตราจารย์ ดร.ณัฐนันท์	ทองทรัพย์	มหาวิทยาลัยเวสเทิร์น
20	ผู้ช่วยศาสตราจารย์ ดร.วรวุฒิ	กังหัน	"มหาวิทยาลัยเทคโนโลยี
21	ผู้ช่วยศาสตราจารย์ ดร.สานิต	ศิริวิศิษฐ์กุล	มหาวิทยาลัยนอร์ทกรุงเทพ
22	ผู้ช่วยศาสตราจารย์ ดร.อนันต์	ธรรมชาลัย	มหาวิทยาลัยนอร์ทกรุงเทพ
23	ผู้ช่วยศาสตราจารย์ ดร. ตระกูล	จิตวัฒนากร	มหาวิทยาลัยนอร์ทกรุงเทพ
24	ผู้ช่วยศาสตราจารย์ ดร.ฟ้าวิกร	อินลวง	มหาวิทยาลัยธนบุรี
25	ผู้ช่วยศาสตราจารย์ ดร.วิชุตา	นาคเถื่อน	มหาวิทยาลัยนอร์ทกรุงเทพ
26	ผู้ช่วยศาสตราจารย์ ดร.ภัครดา	เกิดประทุม	มหาวิทยาลัยนอร์ทกรุงเทพ
27	ผู้ช่วยศาสตราจารย์ ดร.พงษ์ศักดิ์	เพชรสถิตย์	มหาวิทยาลัยนอร์ทกรุงเทพ
28	ผู้ช่วยศาสตราจารย์ประสงค์	อุทัย	มหาวิทยาลัยธนบุรี
29	ผู้ช่วยศาสตราจารย์ พิพัฒน์	เลิศโกวิทย์	มหาวิทยาลัยธนบุรี
30	ผู้ช่วยศาสตราจารย์ ดร.กรัณย์พัฒน์	อิ่มประเสริฐ	มหาวิทยาลัยราชพฤกษ์
31	ผู้ช่วยศาสตราจารย์ บัญชา	ศรีวิโรจน์	มหาวิทยาลัยธนบุรี
32	ผู้ช่วยศาสตราจารย์ จิรศักดิ์	ส่งบุญแก้ว	มหาวิทยาลัยธนบุรี
33	ผู้ช่วยศาสตราจารย์วารุณี	มิลินทปัญญา	มหาวิทยาลัยธนบุรี
34	ผู้ช่วยศาสตราจารย์ พรณรงค์	สิงห์สำราญ	มหาวิทยาลัยนอร์ทกรุงเทพ
35	ผู้ช่วยศาสตราจารย์ พิชัย	เหลี่ยวเรืองรัตน์	มหาวิทยาลัยฟาร์อีสเทอร์น
36	ผู้ช่วยศาสตราจารย์ ธัญญารัตน์	ลิ้นฤาษี	มหาวิทยาลัยฟาร์อีสเทอร์น
37	ผู้ช่วยศาสตราจารย์ ทิพย์วรรณ์	ทนันไชย	มหาวิทยาลัยฟาร์อีสเทอร์น
38	ผู้ช่วยศาสตราจารย์ เจนจิรา	ถาปินตา	มหาวิทยาลัยฟาร์อีสเทอร์น
39	ผู้ช่วยศาสตราจารย์ สุรกิจ	คำวงศ์ปิน	มหาวิทยาลัยนอร์ท-เชียงใหม่
40	ผู้ช่วยศาสตราจารย์วีระพงศ์	เชาวลิต	มหาวิทยาลัยเซาธ์อีสท์บางกอก
41	ผู้ช่วยศาสตราจารย์ ดร.ธนิต	แต่งศรี	มหาวิทยาลัยธนบุรี
42	ผู้ช่วยศาสตราจารย์ ดร.สมจินต์	อักษรธรรม	มหาวิทยาลัยธนบุรี
43	ดร.ฐิติพร	กรัยวิเชียร	มหาวิทยาลัยธนบุรี
44	ดร.วุฒิ	วัชโรดมประเสริฐ	มหาวิทยาลัยธนบุรี
45	ดร.เสาวภา	เมืองแก่น	มหาวิทยาลัยธนบุรี
46	ดร.ปริษฐา	ถนอมเวช	มหาวิทยาลัยธนบุรี
47	ดร.พัทธนันท์	ตั้งวรรณวิทย์	มหาวิทยาลัยธนบุรี

ด้านสังคมศาสตร์และสหวิทยาการ (ต่อ)

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48	ดร.ทมนี	สุขใส	มหาวิทยาลัยธนบุรี
49	ดร.ธนวรรณ	แฉ่งขำโฉม	มหาวิทยาลัยธนบุรี
50	ดร.วรเทพ	ตรีวิจิตร	มหาวิทยาลัยธนบุรี
51	ดร.สุกฤษฎิ์	ลิมโพธิ์ทอง	มหาวิทยาลัยนอร์ท-เชียงใหม่
52	ดร.พงศ์ศิริ	คำขันแก้ว	มหาวิทยาลัยนอร์ท-เชียงใหม่
53	ดร.สุธีรา	ศรีเบญจโชติ	มหาวิทยาลัยนอร์ท-เชียงใหม่
54	ดร.จตุพร	วงศ์มหาดเล็ก	มหาวิทยาลัยนอร์ท-เชียงใหม่
55	ดร.พัชราภรณ์	ลิมปิอังคนันต์	มหาวิทยาลัยนอร์ท-เชียงใหม่
56	ดร.ธรรมนูญ	พ่อค้าทอง	มหาวิทยาลัยนอร์ท-เชียงใหม่
57	Dr.Lloyd	Nwafor	มหาวิทยาลัยนอร์ท-เชียงใหม่
58	ดร.พลอยพัชชา	โค้วสุวรรณกิจ	มหาวิทยาลัยนอร์ท-เชียงใหม่
59	ดร.ศิริพงษ์	มาณะศรี	มหาวิทยาลัยนอร์ท-เชียงใหม่
60	ดร.พัทธ์ธีรา	จิรอุดมสาโรจน์	มหาวิทยาลัยกรุงเทพสุวรรณภูมิ
61	ดร.วฤดดา	สังวรกิตติวุฒิ	มหาวิทยาลัยกรุงเทพสุวรรณภูมิ
62	ดร.ชนิตา	เอี่ยมสอาด	มหาวิทยาลัยกรุงเทพสุวรรณภูมิ
63	ดร.พสุ	ชัยเวฬุ	มหาวิทยาลัยเซาธ์อีสท์บางกอก
64	ดร.ณฐา	ธรเจริญกุล	มหาวิทยาลัยเซาธ์อีสท์บางกอก
65	ดร.เอกนรี	ทุมพล	มหาวิทยาลัยเซาธ์อีสท์บางกอก
66	ดร.รวมพล	จันทศาสตร์	มหาวิทยาลัยเซาธ์อีสท์บางกอก
67	ดร.ศิถา	ปัญญวัชรวงศ์	มหาวิทยาลัยเซาธ์อีสท์บางกอก
68	ดร.ปิยดา	โพธิ์ศรี	มหาวิทยาลัยราชภัฏเทพสตรี
69	ดร.พนัส	อุณหบัณฑิต	มหาวิทยาลัยธนบุรี
70	ดร.พิสมัย	เหล่าไทย	มหาวิทยาลัยธนบุรี
71	ดร.ประจักษ์	พรมงาม	มหาวิทยาลัยราชภัฏสวนสุนันทา
72	ดร.พิชา	พันธุ์มงคล	มหาวิทยาลัยธนบุรี
73	ดร.จริมจิต	เกิดบ้านชัน	มหาวิทยาลัยนอร์ทกรุงเทพ
74	ดร.ศิริชัย	จันพุ่ม	มหาวิทยาลัยนอร์ทกรุงเทพ
75	ดร.วิจิตรา	บุญแล	มหาวิทยาลัยนอร์ทกรุงเทพ
76	ดร. สุภารักษ์	จูตระกูล	มหาวิทยาลัยนอร์ทกรุงเทพ
77	ดร.พินิจ	แกล้วเกษตรกรณ์	มหาวิทยาลัยนอร์ทกรุงเทพ
78	ดร.ปัญญาวัฒน์	จุฑามาศ	มหาวิทยาลัยนอร์ทกรุงเทพ

ด้านสังคมศาสตร์และสหวิทยาการ (ต่อ)

ลำดับ	ชื่อ-นามสกุล		สถาบัน
79	ดร.พิเชษ	แตงอ่อน	มหาวิทยาลัยนอร์ทกรุงเทพ
80	ดร.พีระยุทธ	คุ้มศักดิ์	มหาวิทยาลัยนอร์ทกรุงเทพ
81	ดร.ธีรเดช	สนองทวีพร	มหาวิทยาลัยนอร์ทกรุงเทพ
82	ดร.นพรัตน์	น้อยเจริญ	มหาวิทยาลัยนอร์ทกรุงเทพ
83	ดร.อาภากร	เปรี้ยวนิ่ม	มหาวิทยาลัยนอร์ทกรุงเทพ
84	ดร.สุมนทิพย์	บุญเกิด	มหาวิทยาลัยนอร์ทกรุงเทพ
85	ดร.พิเชษ	แตงอ่อน	มหาวิทยาลัยนอร์ทกรุงเทพ
86	อ.ทพ.ชญปัฒญ์	ซิมสุชิน	มหาวิทยาลัยเนชั่น
87	อ.ทพญ.สิริพร	สาสกุล	มหาวิทยาลัยเนชั่น
88	พ.ต.ทพ.ดร.อานันท์	จักรอิศราพงศ์	มหาวิทยาลัยเนชั่น

ผู้ทรงคุณวุฒิพิจารณาบทความ

ด้านเทคโนโลยีสารสนเทศ

ลำดับ	ชื่อ-นามสกุล		สถาบัน
1	รองศาสตราจารย์ ดร.คณิศา	โชติจันทึก	มหาวิทยาลัยอุบลราชธานี
2	ผู้ช่วยศาสตราจารย์ ดร.สุดาสวรรค์	งามมงคลวงศ์	มหาวิทยาลัยเซาธ์อีสท์บางกอก
3	ผู้ช่วยศาสตราจารย์ ดร.พ.อ.อ.สุริยะ	พุ่มเฉลิม	มหาวิทยาลัยเซาธ์อีสท์บางกอก
4	ผู้ช่วยศาสตราจารย์ ดร.พงศ์กร	จันทราช	มหาวิทยาลัยฟาร์อีสเทอร์น
5	ผู้ช่วยศาสตราจารย์สุรเดช	บุญลือ	มหาวิทยาลัยนอร์ทกรุงเทพ
6	ผู้ช่วยศาสตราจารย์พุทธินันท์	นาคสุข	มหาวิทยาลัยนอร์ทกรุงเทพ
7	ดร.สุพัฒนวรี	ทิพย์เจริญ	มหาวิทยาลัยฟาร์อีสเทอร์น
8	ดร.วัชรพงษ์	ณ เชียงใหม่	มหาวิทยาลัยนอร์ท-เชียงใหม่
9	ดร.ธณพิชญ์	เป็กเยียน	มหาวิทยาลัยกรุงเทพสุวรรณภูมิ
10	ดร.ธีระพล	ลิ้มศรัทธา	มหาวิทยาลัยเซาธ์อีสท์บางกอก
11	ดร.ทรงพล	นคเรศเรืองศักดิ์	มหาวิทยาลัยเซาธ์อีสท์บางกอก
12	ดร.สันติ	โสภาประดิษฐ์	มหาวิทยาลัยเซาธ์อีสท์บางกอก
13	ดร.ปริพัส	ศรีสมบูรณ์	มหาวิทยาลัยราชภัฏนครปฐม
14	ดร.เอนก	นามขันธ์	มหาวิทยาลัยธนบุรี
15	ดร. อมรวิทย์	วัชรพฤกษาดี	มหาวิทยาลัยนอร์ทกรุงเทพ
16	ดร. ณปภัช	วชิรกลิ่นขจร	มหาวิทยาลัยนอร์ทกรุงเทพ

Opening Remarks The 16th National and International Academic Conference

"Benjamitr Wichakarn" under the theme "Innovation and Learning for an Aging Society"

By Assistant Professor Dr. Sittiporn Prawatruangruang

Friday, March 27, 2026

At Sattabongkot Room, North Bangkok University, Rangsit Campus

Distinguished Guests,

Representatives of the Association of Private Higher Education Institutions of Thailand, President of the Thailand Association for Educational Communications and Technology (Thai AECT), Executives from the Benjamitr Academic Network, Associate Professor Dr. Anak Khantachawana, Distinguished Speaker and Expert in National Research and Innovation for Aging Society from the National Research Council of Thailand (NRCT), Faculty members, researchers, students, and all honored guests,

On behalf of North Bangkok University, it is both an honor and a great pleasure for me to preside over the opening ceremony of the 16th Benchamit Academic Conference, held at both the national and international levels.

The 16th Benchamit Academic Conference reflects the strength of academic collaboration among higher education institutions. This conference serves not only as a platform for presenting research findings and scholarly works, but also as an important milestone that demonstrates the strong partnership among the Benchamit Academic Network, the Association of Private Higher Education Institutions of Thailand (APHEIT), and the Thai Association for Educational Communications and Technology (Thai AECT).

As we are all aware, the world is experiencing rapid transformation driven by technological advancement and significant changes in economic, social, cultural, and political landscapes. In this context, it is particularly meaningful that private higher education institutions have come together to organize this national and international conference under the theme "**Innovation and Learning for an Aging Society**."

This theme is highly relevant to the current situation, as Thailand and many countries around the world are entering an aging society. Developing innovative solutions and promoting lifelong

learning are no longer merely options; they have become necessities. These efforts are essential for enhancing quality of life, maximizing the value of human resources, and addressing the critical question of how innovation can help prepare society—particularly Thai society—to successfully navigate the challenges and opportunities of an aging population with confidence, sustainability, and resilience.

Equally important is the question of how learning throughout all stages of life can become a key mechanism for human resource development without age limitations. Lifelong learning empowers individuals to continue contributing meaningfully to society while adapting to changing social and technological environments.

I sincerely hope that this conference will serve as an important forum for the exchange of knowledge, innovative ideas, and contemporary research among scholars and researchers. It is my expectation that the discussions and findings shared here will contribute to the effective application of technology and innovation in addressing the needs of older adults, while also fostering sustainable academic collaboration among institutions for the long-term advancement of education and society.

I would like to express my sincere appreciation to the organizing committee, the academic committee, and all member institutions of the Benchamit Academic Network for their dedication, hard work, and commitment in making this conference possible here at North Bangkok University.

Now, the auspicious time has arrived. It is my great pleasure to officially declare open the 16th Benchamit Academic Conference (National and International Conference). I wish the conference every success in achieving its objectives, and I hope that all participants will gain valuable knowledge, meaningful experiences, and fruitful collaborations that can be applied for the benefit of their institutions and society.

Report Speech

The 16th Benchamit National and International Academic Conference

"Innovation and Learning for an Aging Society"

By Assistant Professor Dr. Songyot Kaewmongkol

Friday, 27 March 2026

Sattabongkot Hall, North Bangkok University, Rangsit Campus

Honorable Assistant Professor Dr. Sitthiporn Prawatrungruang

President of North Bangkok University, Chairperson of the Ceremony

On behalf of the Organizing Committee of the 16th Benchamit National and International Academic Conference, I would like to express our sincere gratitude to you for kindly honoring us by presiding over the Opening Ceremony and Research Presentation Session of this conference under the theme "Innovation and Learning for an Aging Society."

North Bangkok University is honored to serve as the host institution for this conference in collaboration with the Private Higher Education Institutions Association of Thailand and the Thai Association for Educational Communications and Technology (Thai AECT).

The development of innovation and learning for an aging society has become a crucial issue among the rapid social, economic, and technological transformations of today's world. In particular, Thailand has entered a complete aging society, making the creation of knowledge, the advancement of innovation, and the promotion of lifelong learning essential mechanisms for enhancing the quality of life of citizens and preparing society to adapt sustainably to future changes.

The objectives of this conference are to provide a platform for the dissemination of research findings, the exchange of academic knowledge and experiences, and the strengthening of collaborative networks among academics, researchers, students, and organizations from both Thailand and abroad. The conference offers opportunities for the presentation of scholarly work at both national and international levels across a wide range of disciplines, including science and

technology, social sciences, education, and interdisciplinary studies. It is anticipated that these academic exchanges will contribute to knowledge development, innovation creation, and the practical application of research outcomes for the sustainable development of society in the future.

Now, the auspicious time has arrived. It is my great honor to respectfully invite the Chairperson, Assistant Professor Dr. Sitthiporn Prawatrungruang, and President of North Bangkok University, to deliver the Opening Address and officially declare the 1 6 th Benchamit National and International Academic Conference open.

Conference Schedule

The 16th Benjamit National and International Academic Conference

"Innovation and Learning for an Aging Society"

Friday, March 27, 2026

Sattabongkot Hall, North Bangkok University, Rangsit Campus

08:30 – 09:00	Registration
09:00 – 09:30	Opening Ceremony of the 16th Benjamit National and International Academic Conference Opening Remarks by Asst. Prof. Dr. Sitthiporn Prawatrungruang President of North Bangkok University
09:30 – 09:45	Presentation of Souvenirs to Presidents of Benjamit Network Universities and Handover Ceremony for Hosting the 17th Benjamit National and International Academic Conference
09:45 – 10:00	Announcement of the Best Academic Paper Awards, Year 2026
10:00 – 11:00	Keynote Speech: "Innovation and Learning for an Aging Society" By Dr. Wiparat De-Ong Executive Director, National Research Council of Thailand (NRCT) Ministry of Higher Education, Science, Research and Innovation
11:00 – 12:00	Academic Paper Presentations
12:00 – 13:00	Lunch Break
13:00 – 16:30	Academic Paper Presentations (Continued)
16:30	Closing Ceremony

Note: The schedule is subject to change without prior notice, as appropriate

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Your Perfect Companion Application for Managing Your Calorie Intake

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Abstract

This research aims to develop an Android application to calculate and track daily calorie intake and expenditure. The main programming languages used were JavaScript, SQL, Kotlin, and Dart, along with design and testing tools such as Android Studio and Figma. The goal is to enable users to conveniently manage their health and nutrition, receive appropriate nutritional and exercise recommendations, promote healthy behaviors, and reduce the risk of diseases related to unbalanced nutrition. The population of this study consisted of individuals residing in Bangkok, Thailand, and a sample of 400 participants was selected using simple random sampling. The results show that the application fully meets its objectives, excelling in ease of use, calculation accuracy, and convenient access via mobile devices. However, some limitations remain, such as an incomplete food database and lack of specific recommendations. Future development plans include integration with smart wearable devices and personalized meal recommendations.

Keywords: Application, Managing, Calories

Background and Statement of the problem

In recent years, awareness of health and nutrition has significantly increased among people around the world. One of the main reasons for this growing awareness is the rapid rise in chronic health problems, particularly non-communicable diseases (NCDs) such as obesity, diabetes, cardiovascular disease, and cancer. These diseases have become major public health challenges in the 21st century. In Thailand, the situation is

particularly concerning. According to the World Health Organization (WHO), NCDs—including cardiovascular disease, cancer, diabetes, and chronic respiratory diseases—are the leading causes of death in the country, accounting for approximately 400,000 deaths annually, or about 74% of all deaths. Additionally, around 32% of the Thai population is overweight and 9% is obese, representing one of the highest rates in Southeast Asia (World Health Organization, 2016).

The primary factors contributing to these health problems are excessive energy consumption and insufficient physical activity. Maintaining a proper balance between caloric intake and energy expenditure is therefore an essential mechanism for preventing and controlling these diseases. However, calculating daily energy requirements and monitoring calorie expenditure through different activities can be complex and often requires specialized knowledge. Various factors must be considered, including weight, height, age, gender, physical activity level, and individual health goals.

With the rapid advancement of digital technology, artificial intelligence (AI) and smart health innovations have emerged as important tools for improving personal health management. AI-based health applications can analyze user data, calculate calorie intake and energy expenditure, and provide personalized recommendations for diet and physical activity. These technological innovations make health management more accessible, convenient, and effective for the general population without requiring extensive nutritional knowledge.

Although many calorie-calculating applications are currently available in the global market, most are designed for users in other countries and may not fully align with the lifestyle, dietary habits, and cultural context of Thai people. In addition, some applications are complex or costly, which limits their accessibility and widespread use. Therefore, the development of an AI-driven healthy innovation application that is suitable for the Thai context, user-friendly, and accessible to people at all levels of society is highly necessary. The main idea of this research is to develop a digital health solution that enables individuals to effectively manage calorie intake and physical activity through intelligent technology.

The development of this AI-based health innovation is expected to have a significant impact on improving people's quality of life. By helping individuals better

understand and manage their health behaviors, the application can support the prevention and control of non-communicable diseases, promote sustainable healthy lifestyles, and enhance overall well-being. Furthermore, such technological innovation also supports national public health strategies aimed at reducing the burden of chronic diseases, lowering healthcare costs, and improving the long-term quality of life for the Thai population.

Objective

1. To develop an application that can accurately calculate and track daily calorie intake and expenditure
2. Promoting health care through appropriate nutritional and exercise advice, while supporting the prevention of diseases caused by unbalanced eating habits

Expected benefits

1. Users have various tools to research and track calorie intake without knowing the balance of energy intake and intensity
2. This helps users modify their eating habits to suit their health goals (e.g., weight loss or maintaining fitness)

Conceptual Framework

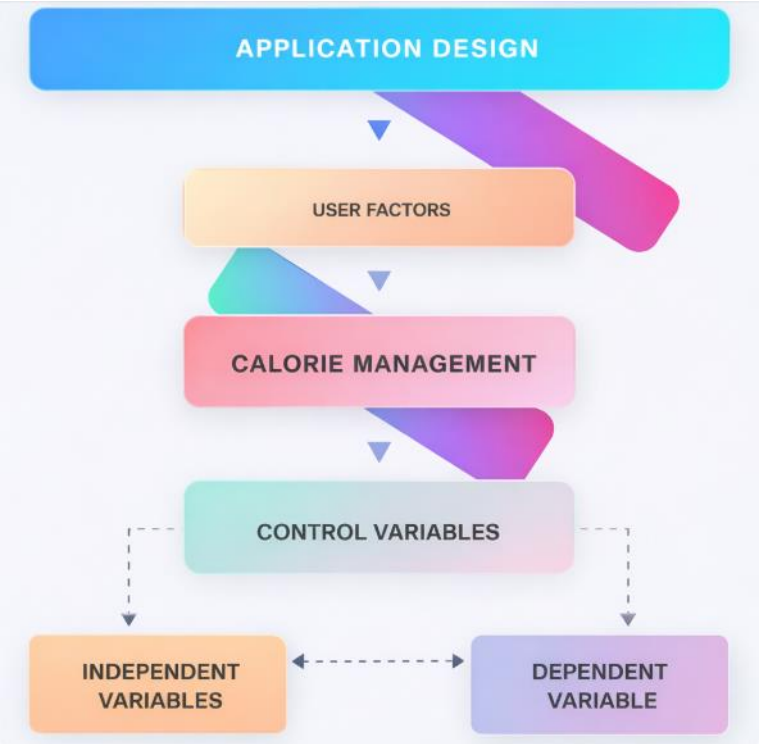


Figure 1 Conceptual Framework

Related Research

Research on calorie counting applications aims to develop a smartphone application tool that allows users to accurately calculate calories consumed and burned, as well as provide knowledge about correct nutrition. This helps users, especially those who want to lose weight or prevent various diseases, make better decisions about healthy eating and plan exercise for weight loss or health control effectively. Therefore, the main objective of the research is to create a tool that helps solve health problems arising from inappropriate food consumption, focusing on raising user awareness and adjusting eating and exercise habits correctly according to nutritional principles (Rung Moolom and Nattapol Kindaw, 2020).

This research on calorie control applications aims to 1) study the development of calorie control applications and 2) determine user satisfaction with calorie control applications. The researchers studied theories related to the project, including the meaning of calories, calorie metabolism, the meaning of body mass index, the

importance of water to the body, and the processes of blood function in the body. In addition, they studied the development of technology systems and programming languages. The calorie control application was developed using Eclipse and Java for greater ease of use. The researchers designed it to be offline so that it can be accessed anywhere without internet access. The researchers began analyzing, designing, and developing the system. The calorie control application is categorized into food groups and can be added to a list of accumulated calories. The application provides calorie information and activity data to help burn energy, calculate body mass index, energy requirements, water needs, and blood volume, allowing users to utilize this information effectively in their daily lives. From the results of the calorie control application development, it can be concluded that the application can function correctly, meets its intended purpose, and demonstrates its capabilities efficiently, ready for practical use (Anongnat Namchomphu, Internet, 2015).

The research on the development of a food recommendation application for weight loss aims to develop an application that assists in the weight loss process, focusing on controlling the amount of food consumed each day to suit the user. This application emphasizes nutritional recommendations and healthy foods to help users effectively control their weight. The goal is for users to choose foods with complete nutrients and reduce the amount of fat and energy accumulated in the body.

The role of this application is to promote knowledge and discipline in eating, as well as making decisions about choosing foods that are appropriate to individual needs, so that users can achieve their weight loss goals and maintain overall health (Wipada Ya-on, Panyaporn Siangyen, Natthasinee Tangsiripaiboon, and Methawat Kawilkrue, 2024).

The research on the project management system for schools under the Nakhon Si Thammarat Primary Educational Service Area aims to develop a project management system. This research aimed to study user satisfaction with a project management system. Nakhian School, under the Nakhon Si Thammarat Primary Educational Service Area 1, was selected as a case study for system development. A purposive sampling method was used, considering the school's personnel readiness and computer network infrastructure. The satisfaction evaluation sample consisted of four schools: Ban Nakhian School, Ban Sarabua School, Ban Khlong Nga School, and Ban Bang Phra School. The

system development followed the principles of the System Development Life Cycle (SDLC) and utilized PHP programming with a MySQL database. The research found a project management system that can serve as a prototype for other schools, preventing data loss, improving work processes efficiency, and ensuring accuracy. Furthermore, the user satisfaction survey revealed a high level of satisfaction across all aspects of the project management system. Based on these findings, the researchers hope this information will be useful in the application of technology. The information will be used to further develop schools under the Nakhon Si Thammarat Primary Educational Service Area (Manoros Borirak Arawin, Sunisa Kidjai, and Jeerawat Naksuwan, 2010).

The research on the development of an information system for managing the Five Precepts Village Project in Nakhon Pathom Province aims to 1) design and develop an information system for managing the Five Precepts Village Project in Nakhon Pathom Province and 2) evaluate user satisfaction with the system. The information system was developed in the form of a web application and the SDLC (System Development Life Cycle) model was used for design and development. Afterwards, the system's efficiency was evaluated by 3 experts, and the user satisfaction of the Five Precepts Village information system was evaluated from a group of users, including officials from the Nakhon Pathom Provincial Buddhist Office and 30 general users (Kairung Hengpraprom, Det Thammasiri, Sutharat Chawanafang, and Supoj Hengpraprom, 2019).

From studying research related to the development of health applications, it was found that calorie calculation applications play an important role in promoting health-care behaviors, focusing on accurately calculating energy consumed and burned, as well as providing appropriate nutritional advice. To help users control their weight and reduce the risk of diseases caused by unbalanced diets (Rung Moolom and Nattapol Kindao, 2020; Wipada Ya-on et al., 2024), this work

Research Methodology

Population, a Sample

The population of this study consisted of individuals residing in Bangkok, Thailand. From this population, a sample of 400 participants was selected using a simple random

sampling method to ensure that every individual in the population had an equal chance of being included in the study.

Data Collection and Study

Existing System Workflow: Describe your system's operation in chronological order.

1) Users must calculate calories from food themselves.
2) Paper or notebooks are used to record calorie consumption.
3) Users do not receive guidance on diet and exercise.
4) Users must track the calorie consumption of those they care for themselves.
5) There is no central system for storing calorie data.

New System Requirements:

1) The system must be able to record and calculate calories consumed.
2) Users can view information and details of daily calorie consumption.
3) Users can view information and guidance on nutrition and exercise.
4) The system can view the user's calorie consumption history.
5) Supports mobile and portable device access.

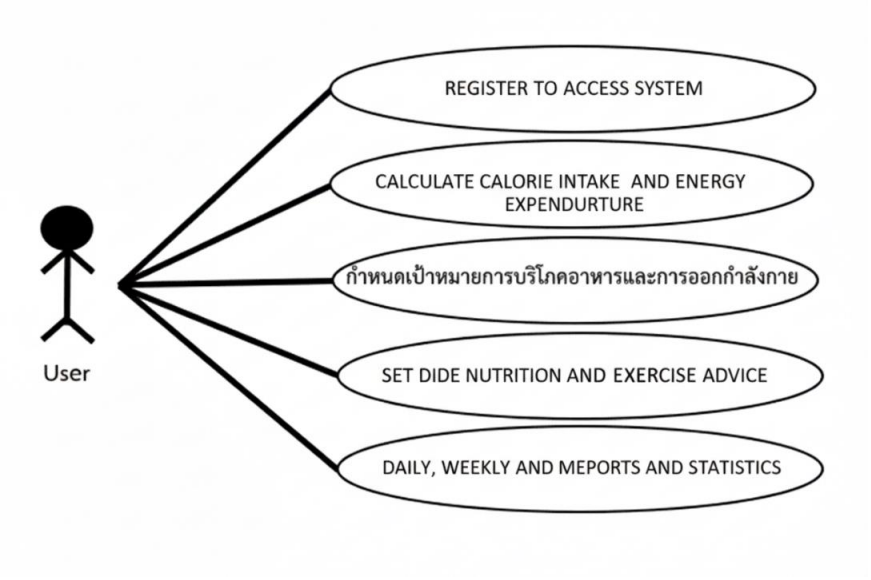


Figure 2 Application screen design

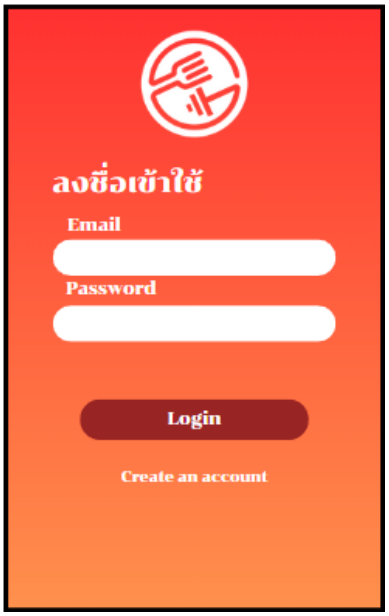


Figure 3 Login screen



Figure 4 Personal information entry screen



Figure 5 Recording menu screen

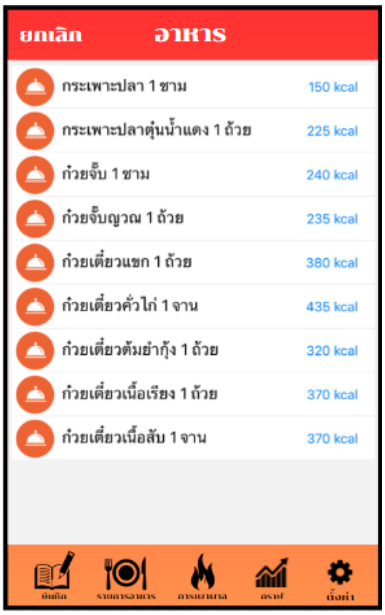


Figure 6 Menu screen



Figure 7 Metabolism screen

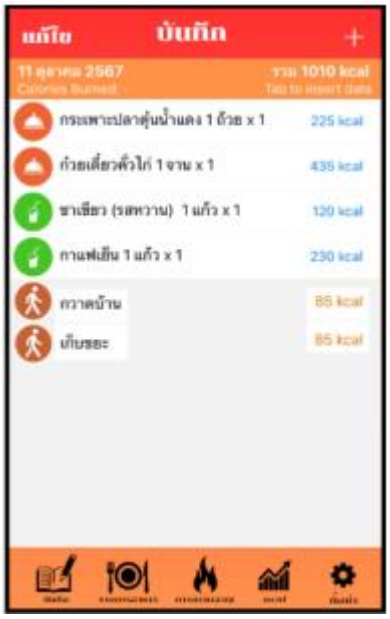


Figure 8 Log entry screen

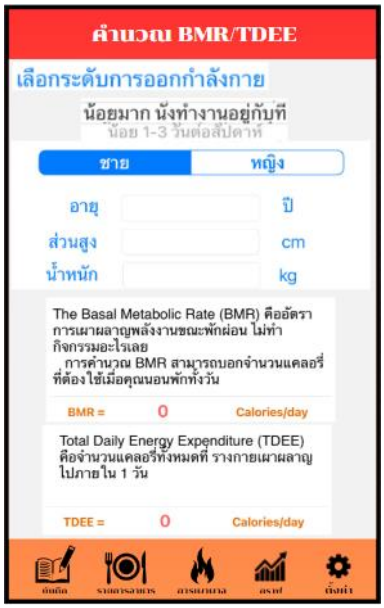


Figure 9 Shows the screen for calculating BMR and TDEE

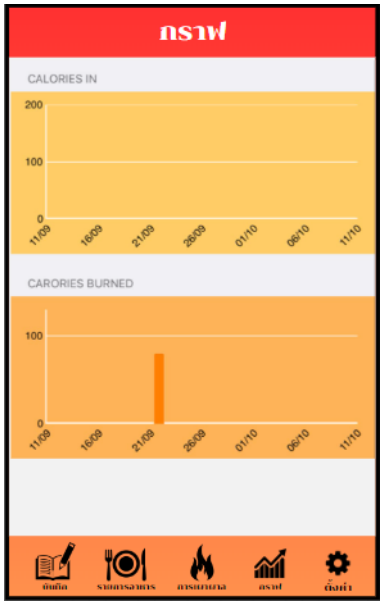


Figure 10 Screen displaying the graph menu

Research Results

The results of this study indicate that the developed application can effectively calculate and track users' daily calorie intake and energy expenditure with a high level of accuracy. The system allows users to input personal information such as age, weight, height, gender, and activity level, which is used to calculate Basal Metabolic Rate (BMR) and Total Daily Energy Expenditure (TDEE). In addition, the application promotes health care by providing nutritional guidance and exercise recommendations to support balanced eating behaviors and encourage regular physical activity, which can help prevent diseases related to unhealthy dietary habits. The application is easy to use, provides fast automatic calculations, and can be accessed conveniently via mobile devices. However, some limitations remain, including an incomplete food database, general nutritional recommendations that may not suit all user groups, and the lack of a notification or motivation system to encourage continuous use. Future development should focus on integrating wearable device connectivity, linking with healthcare systems for personalized health monitoring, and developing meal planning features that align with users' daily calorie needs.

Summary

User Evaluation Table

Instructions: Please rate your satisfaction with the system in each aspect from 1 to 5, where:

- 1 = Not satisfied at all
- 2 = Not satisfied
- 3 = Moderate
- 4 = Satisfied
- 5 = Most satisfied

Table 1 User Evaluation

ASSESSMENT CRITERIA	USER 1	USER 2	USER 3	USER 4	USER 5	AVG.	SATISFACTION LEVEL
1. overall system usability							
***1.1** ease of access and use*	5	4	5	5	4	4.6	Strongly Satisfied
***1.2** speed of processing*	4	3	4	4	5	4.0	Satisfied
***1.3** data reliability*	5	5	5	4	5	4.8	Strongly Satisfied
2. application design							
***2.1** visual aesthetics (ui)*	4	5	4	5	4	4.4	Satisfied
***2.2** convenience of use (ux)*	5	4	5	5	4	4.6	Strongly Satisfied
***2.3** clarity of text and icons*	5	5	4	4	5	4.6	Strongly Satisfied
3. calorie management							
***3.1** accuracy of calorie calculation*	4	4	5	5	4	4.4	Satisfied
***3.2** ease of data logging*	4	5	5	4	5	4.6	Strongly Satisfied
***3.3** benefits of using features*	5	5	4	5	5	4.8	Strongly Satisfied

Summary of Evaluation Results

• Overall System Usability: The average score is high (4.0-4.8), considered "satisfactory" to "most satisfied," indicating that the system is easy to use, fast, and presents information well.

• Application Design: The average score is 4.4-4.6, considered "satisfactory" to "most satisfied," indicating that the user interface (UI/UX) is aesthetically pleasing and user-friendly.

• Calorie Management: The average score is 4.4-4.8, considered "satisfactory" to "most satisfied," indicating that the system can accurately calculate and record data, and users greatly benefit from using this feature

Overall Summary:

Evaluations from 5 users indicate that the system is well-designed and developed in all aspects, including overall usability, design, and calorie management functions. All areas received an average score above 4.0, reflecting a level of user satisfaction ranging from "satisfactory" to "most satisfied" with the system.

Expert Evaluation Table

Instructions: Please rate your opinion on each aspect of the system from 1 to 5, where:

- 1 = Needs significant improvement
- 2 = Needs improvement
- 3 = Acceptable
- 4 = Good
- 5 = Excellent

Table 2 Expert Evaluation

Assessment Criteria	*Expert 1*	*Expert 2*	*Expert 3*	*Avg.*	*Quality Level*
1. Usability					
1.1 Smooth and error-free operation	5	4	5	4.67	Excellent
1.2 Consistency with standards	4	5	4	4.33	Good
1.3 User data security	5	5	5	5.00	Excellent
2. UI/UX Design					
2.1 Aesthetics and layout	4	5	4	4.33	Good
2.2 Intuitive and simple design	5	4	5	4.67	Excellent
2.3 Responsiveness	5	5	4	4.67	Excellent
3. Functionality (Calorie Management)					
3.1 Accuracy of formula calculation	5	5	5	5.00	Excellent
3.2 Diversity of food menu coverage	4	4	5	4.33	Good
3.3 Appropriateness of recommendations	5	5	4	4.67	Excellent

Findings

1. System Usability: The evaluation results indicate that the system usability received a very high average score ranging from 4.67 to 5.00, which is rated at the "Excellent" level. This finding shows that the application operates correctly, effectively meets user requirements, and complies with expected system standards.

2. Application Design (UI/UX): The application design was evaluated with an average score ranging from 4.33 to 4.67, which falls between the "Good" and "Excellent" levels. This result indicates that the application has a well-organized layout, user-friendly interface, and responsive display that can adapt effectively across different devices.

3. Overall System Quality: The overall evaluation conducted by three experts demonstrates that the developed system has high quality in both performance and design aspects. All evaluation criteria received average scores above 4.00, confirming that the application is reliable and capable of effectively meeting user needs.

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The Influence of Leader-Member Exchange Quality on the Exhibition of Organizational Citizenship Behavior: A Systematic Literature Review

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Abstract

This article aims to analyze and synthesize the influence of leader-member exchange (LMX) relationship quality on the exhibition of organizational citizenship behavior (OCB) using a systematic literature review and integrative analysis approach. Within the theoretical framework of social psychology and social exchange theory, the study examined academic articles and research papers published between 2016 and 2026 to ensure contemporary relevance. The methodology involves a systematic screening and content analysis of selected peer-reviewed sources.

The findings, categorized by research objectives, demonstrate that high-quality LMX significantly engenders perceived organizational support (POS) and trust in leadership. These elements function as critical mediating mechanisms that lead to the manifestation of OCB across multiple dimensions, including altruism, sportsmanship, and conscientiousness. The conclusion underscores the imperative for leaders to cultivate and sustain exchange relationships characterized by mutual trust and respect. Such relationships enhance psychological commitment and drive extra-role behaviors, which are essential for organizational success and sustainability in the context of a smart ageing society.

Keywords: Leader-Member Exchange (LMX), Organizational Citizenship Behavior (OCB), Trust in Leadership, Perceived Organizational Support (POS), Systematic Review

Introduction

Over the past decade, organizations worldwide have confronted increasingly intense waves of challenges within rapidly evolving and unpredictable contexts, commonly described by the acronym (Volatility, Uncertainty, Complexity, and Ambiguity). This state of volatility and uncertainty has rendered business operations and human resource management extraordinarily complex. Organizations aspiring to survive and achieve sustainable growth can no longer rely solely on in-role performance as stipulated in employment contracts. The VUCA era demands that employees exercise initiative, demonstrate flexibility, and remain prepared to assist colleagues and the organization in unforeseen circumstances. Consequently, organizations necessarily depend upon the exhibition of Organizational Citizenship Behavior, which refers to behaviors that transcend formal job requirements yet contribute to overall organizational effectiveness (Organ, 1988). functions as social "lubricant" that facilitates smoother and more efficient organizational functioning amidst tension and confusion. These behaviors encompass assisting coworkers, voluntarily participating in organizational activities, or offering constructive suggestions for organizational development without direct compensation. Within crisis situations and uncertaint, the most significant limitation of traditional management approaches lies in reliance upon bureaucratic control and hierarchical command structures, which typically fail to adapt sufficiently to rapid changes. Organizations cannot develop manuals encompassing all novel problems emerging daily. It is precisely at this juncture that Leader-Member Exchange quality assumes a critical role as the organization's 'flexibility mechanism. theory demonstrates that when leaders establish high-quality relationships founded upon trust and reciprocity rather than merely contractual obligations, employees develop psychological safety. This security serves as the key that unlocks employees' willingness to make immediate decisions in addressing emergent problems and exhibit helping behaviors toward colleagues without awaiting directives. These proactive behaviors constitute the most essential elements enabling organizations to navigate the volatility of the VUCA era. Within this context where OCB has become essential, Leader-Member Exchange quality has gained recognition as one of the most significant causal variables in predicting employee behavior (Graen & Uhl-Bien, 1995). proposes a conceptualization distinct from traditional

leadership perspectives by demonstrating that leaders do not establish uniform relationships with all followers but rather create differentiated relationships with individual subordinates. These variations exert profound impacts upon employees' work-related attitudes and behaviors.

LMX theory categorizes leader-member relationships into two principal types:

In-Group (High-Quality LMX) This relationship develops from exchanges that transcend contractual obligations (social exchange). Members of this group receive greater trust, support, information, and opportunities for decision-making participation from leaders. Leaders invest in these relationships and expect members to reciprocate through dedication, loyalty, and exhibition of behaviors exceeding role requirements, such as OCB. And Out-Group (Low-Quality LMX) This relationship is founded upon contractual exchange (economic exchange). Members of this group receive treatment strictly according to prescribed rules and duties. Communication remains limited to formal work matters, and they receive less trust and fewer opportunities compared to the In-Group. This differentiation in LMX quality holds profound significance for OCB emergence. Employees maintaining high-quality LMX relationships typically experience obligation to reciprocate toward leaders and the organization through citizenship behavior exhibition, as they perceive that the organization and leaders have provided care and support exceeding contractual stipulations. Numerous studies thus confirm that LMX relationship quality constitutes a robust predictor of OCB, serving as a critical mechanism enabling organizations to cultivate human resources willing to dedicate themselves to the organization beyond assigned duties—a vital attribute that VUCA-era organizations require to maintain competitive capability and adaptive agility. Understanding the mechanisms through which LMX relationships influence OCB exhibition therefore represents a crucial issue in contemporary management. This research aims to explore and analyze the causal relationship between LMX and OCB comprehensively, providing empirical evidence for developing practical approaches whereby organizational leaders can establish quality relationships with employees, ultimately leading to enhanced overall organizational effectiveness.

Research Objectives

1. To synthesize the theoretical framework linking Leader-Member Exchange (LMX) with Organizational Citizenship Behavior (OCB) based on Social Exchange Theory.

2. To analyze the mediating mechanisms, specifically Perceived Organizational Support (POS) and Trust in Leadership, that connect high-quality LMX to OCB.

3. To propose strategic recommendations for executives to enhance LMX quality as a driver for promoting OCB within organizations.

Scope of the Study

This study encompasses conceptual analysis and synthesis of empirical research findings published in leading international and national academic journal databases, including Web of Science, Scopus, PsycINFO, and Thai-Journal Citation Index (TCI).

Document selection focuses upon articles published in high-quality journals such as the Journal of Applied Psychology, The Leadership Quarterly, and Academy of Management Journal, covering the past 20 years. Primary search keywords include Leader-Member Exchange (LMX), Organizational Citizenship Behavior (OCB), with related secondary terms including Leadership, Behavior, and Organization, to obtain comprehensive data aligned with research objectives.

Literature Review and Conceptual Framework

Leader-Member Exchange (LMX) Theory

LMX focuses upon dyadic relationships between leaders and followers that develop over time. High-quality LMX is characterized by higher reciprocity, mutual trust, respect, and affective commitment, with these exchanges typically exceeding contractual stipulations (Graen & Uhl-Bien, 1995).

Organizational Citizenship Behavior (OCB)

OCB is categorized into multiple dimensions. Organ (1997) identified five dimensions of organizational citizenship behavior, as presented in Table 1.

Table 1: Dimensions of Organizational Citizenship Behavior (OCB) and Relationships with LMX

OCB Dimension	Definition	Behavioral Examples	LMX (In-Group) Linkage
1. Altruism	Assisting coworkers in specific tasks voluntarily, beyond job description requirements	• Mentoring newcomers • Assisting colleagues with computer problems • Sharing workload with busy colleagues	In-Group members receive kindness from leaders and reciprocate this kindness toward coworkers (Reciprocity)
2. Sportsmanship	Accepting imperfect environmental conditions or inconveniences without complaining or expressing dissatisfaction	• Refraining from complaints regarding slow equipment • Accepting constructive criticism • Avoiding organizational disparagement	Trust in leaders enables members to reduce suspicion and overlook minor problems for larger objectives
3. Conscientiousness	Performing work exceeding minimum standards, demonstrating high responsibility even without supervision	• Arriving early/staying late to complete tasks • Not utilizing work time for personal matters • Maintaining organizational property diligently	Members must preserve the trustworthiness bestowed by leaders, thus demonstrating dedication to avoid disappointing leadership
4. Courtesy	Actions preventing problems for others or providing advance notification	• Informing colleagues before submitting modified work files • Consulting team members before decisions • Avoiding disturbing others	Related to interactional justice: when leaders show respect, members learn to respect and consider others following this example

OCB Dimension	Definition	Behavioral Examples	LMX (In-Group) Linkage
5. Civic Virtue	Participating responsibly in organizational life and maintaining organizational image comprehensively	• Participating in company volunteer activities • Following organizational announcements/news • Suggesting work improvement methods	In-Group members feel they are "part of" the team, thus willingly protecting and developing their home (organization)

Source: Summarized and adapted from Organ (1988) and Podsakoff et al. (2000)

Linking Mechanism: Social Exchange Theory

Social Exchange Theory (SET) (Blau, 1964) provides the foundational explanation for this connection. When employees perceive that their leaders (or organization) provide support, resources, trust, and equitable treatment (socioemotional exchange), employees experience obligation to reciprocate through positive behaviors, including OCB exhibition—behaviors that cannot be mandated.

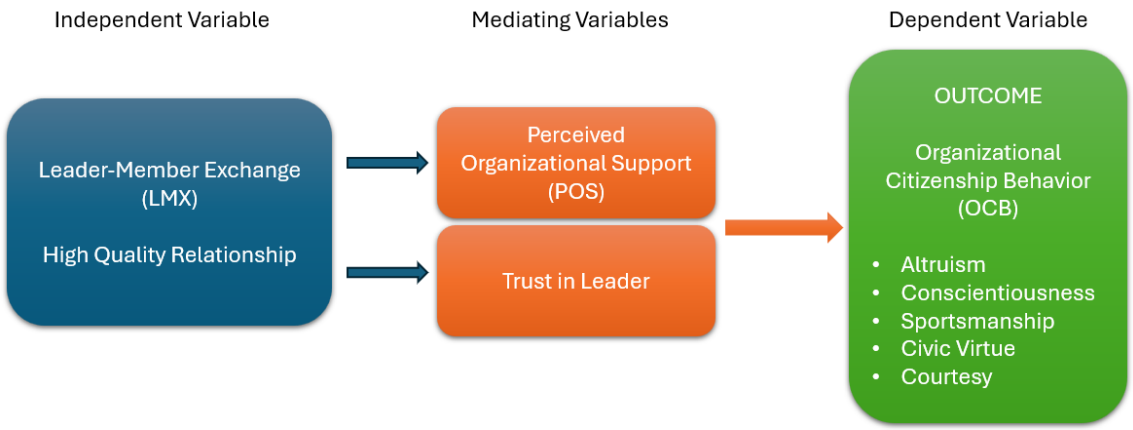


Figure 1: Conceptual Framework

[Conceptual framework diagram illustrating the relationships between LMX, mediating variables (Trust in Leader, POS, Procedural Justice, Interactional Justice), and OCB dimensions]

Research Methodology

This study employs a documentary research design using a systematic literature review approach. The methodology focuses on identifying, evaluating, and synthesizing scholarly evidence regarding the relationship between Leader-Member Exchange (LMX) and Organizational Citizenship Behavior (OCB).

The search strategy involved systematic queries across academic databases, including Scopus, ScienceDirect, and ThaiJO, using keywords such as "LMX," "OCB," and "Social Exchange Theory." The inclusion criteria were limited to peer-reviewed articles and scholarly research published between 2016 and 2026 to ensure contemporary relevance within the context of a smart ageing society. Following a rigorous screening process based on content alignment and theoretical contribution, a total of 9 high-quality articles were selected for final synthesis through content analysis and integrative modeling.

The Role of Perceived Organizational Support (POS)

High-quality LMX is frequently interpreted as a primary signal of organizational support, conveyed through leaders acting as organizational agents. Eisenberger et al. (2002) emphasized that employees experiencing high-quality LMX perceive that the organization inherently values their contributions and cares about their well-being (Perceived Care and Value). This psychological perception functions as a catalyst, stimulating employees to reciprocate with loyalty and extra-role efforts. This reciprocation is specifically manifested through OCB-O (Organizational Citizenship Behavior directed toward the Organization), which is vital for long-term organizational stability.

LMX and Trust in Leadership

Extensive literature confirms that high-quality LMX serves as a principal predictor of trust in leadership (Dirks & Ferrin, 2002). Within the framework of social exchange, trust-based relationships create a sense of psychological safety for followers. This security encourages them to exhibit potentially risky yet beneficial behaviors, such as expressing critical opinions for organizational improvement (Civic Virtue) or exerting additional effort to assist colleagues (Altruism). The synthesis indicates that trust is a critical bridge that converts the quality of the leader-follower relationship into tangible organizational citizenship actions.

Procedural Justice

Within the LMX context, distributive justice may differ between In-Group and Out-Group members. However, procedural justice—referring to transparency and equality in decision-making processes (Colquitt et al., 2001)—is typically perceived positively within high-LMX groups, fostering feelings of shared ownership and willingness to comply with organizational rules and normative behaviors (Conscientiousness).

Interactional Justice: Affective Linking Variable

Beyond trust and support, research reveals that LMX quality directly affects members' perceptions of interactional justice. Specifically, in high-quality relationships, leaders not only provide resources but also bestow "dignified treatment" through respectful communication (Interpersonal Justice) and straightforward explanations for various decisions (Informational Justice).

When employees perceive that leaders respect and value them as individuals rather than merely as working mechanisms, they develop emotional attachment and desire to maintain that relationship. This motivation translates into action through organizational citizenship behavior (OCB), particularly in the dimensions of courtesy and altruism, as reciprocation for the kindness and respect received from leaders.

Summary of New Knowledge Derived from Synthesis

This integrative analysis not only confirms the positive influence between LMX and OCB but also yields significant new academic insights regarding the operation of more complex "psychological mechanisms," as follows:

1. Discovery of Justice-Related Linking Variables: This study extends existing understanding by demonstrating that LMX significantly affects OCB through interactional justice. That is, when leaders show respect and communicate sincerely (High LMX), employees develop perceptions of interpersonal fairness—a subtle psychological mechanism distinct from structural or distributive justice—which serves as a primary stimulus for willingness to reciprocate through OCB.

2. Network of Collaborating Mediating Variables: Leader-member relationships do not operate in isolation but rather exert influence through an interconnected network

of sentiments, including trust in leadership, perceived organizational support, and interactional justice, which collectively transform quality relationships into psychological contracts that employees maintain toward the organization.

3. Differential Effects Specificity: LMX quality exerts particularly pronounced influence upon affective-driven OCB dimensions, namely altruism and courtesy, reflecting that social attachment within the In-Group directly affects interpersonal caring more than regulatory strictness.

4. New Perspective on Human Capital Investment: Strategically, LMX creation should be viewed as "social capital investment" yielding returns in the form of proactive employee behaviors—intangible yet highly valuable assets that cannot be created through financial compensation alone.

Results and Findings

The systematic review of the selected literature reveals several key findings aligned with the research objectives:

1. Theoretical Framework of LMX and OCB (Objective 1) The synthesis confirms that Social Exchange Theory (SET) remains the primary framework for understanding the LMX-OCB relationship. High-quality LMX, characterized by mutual trust, respect, and obligation, transcends formal job descriptions. When leaders provide emotional and professional resources, followers feel a psychological debt that they repay through extra-role behaviors or Organizational Citizenship Behavior (OCB).

2. Mediating Mechanisms: POS and Trust (Objective 2) The analysis identifies two critical mediators: Perceived Organizational Support (POS): Followers in high-quality LMX relationships view their leader as an agent of the organization. Consequently, the support received from the leader is perceived as support from the organization itself, fostering a desire to contribute to organizational goals (OCB-O). Trust in Leadership: Trust acts as a psychological safety mechanism. When employees trust their leaders, they are more willing to engage in altruistic acts and "Civic Virtue" (offering constructive suggestions), as they do not fear negative repercussions.

3. Strategic Approaches for Enhancing LMX (Objective 3) The review suggests that to promote OCB, executives must move beyond transactional management. Strategic

approaches include implementing mentorship programs, encouraging open communication, and fostering a culture of "Perceived Care and Value." These strategies are particularly vital in the context of a smart ageing society, where intergenerational collaboration depends heavily on the quality of exchange between leaders and members.

Conclusion

In conclusion, this systematic review provides compelling evidence that the quality of Leader-Member Exchange (LMX) is a fundamental driver of Organizational Citizenship Behavior (OCB). Based on the synthesis of selected scholarly literature, it is evident that high-quality LMX does not merely influence OCB in isolation but operates through a complex interplay of psychological mechanisms. The integration of Social Exchange Theory suggests that when leaders provide high-quality exchange, followers feel a sense of indebtedness, which they reciprocate through extra-role behaviors (Organ, 1997). Specifically, this review highlights that Trust in Leadership acts as a critical safety net, allowing employees to engage in altruistic acts and "Civic Virtue" without fear of vulnerability (Dirks & Ferrin, 2002). Furthermore, the role of Perceived Organizational Support (POS) as a mediator underscores that followers view their leader's support as a direct reflection of the organization's care, thereby fostering long-term loyalty and commitment (Eisenberger et al., 2002). While this review is grounded in 9 high-quality sources, the findings offer a robust conceptual framework for executives. To sustain organizational success in a smart ageing society, leaders must transition from transactional supervision to relationship-based leadership that prioritizes mutual trust and respect. Future research is encouraged to conduct empirical validations across diverse industrial sectors in Thailand to further strengthen these theoretical linkages.

Practical Recommendations

1. Leadership Training

Organizations should establish leadership development programs emphasizing the creation and maintenance of high-quality LMX relationships, particularly training in interactional communication skills and conflict management. Relationship assessment

should be conducted regularly at the dyadic level to identify problematic relationships and provide necessary support.

Example Activities:

- "Weekly Check-in" Beyond Work Matters: Leaders should allocate time for one-on-one conversations of at least 15-30 minutes weekly, dedicating the initial 50% to inquiring about personal concerns, anxieties, or life goals, demonstrating sincerity and building trust before discussing work matters.

- Collaborative Job Crafting: Provide opportunities for team members to participate in designing work methods or modifying job scope to align with their strengths. This activity cultivates ownership feelings and perceived organizational support, stimulating enhanced conscientiousness.

2. Trust Culture Development

Organizations should cultivate cultures emphasizing transparency, fairness, and risk acceptance (psychological safety) to enable OCB flourishing.

Example Activities Stimulating Civic Consciousness (Fostering OCB & Altruism):

- Culture of Appreciation: Encourage "Kudos Card" writing or verbal colleague appreciation in team meetings to transform helping behaviors (Altruism) into accepted and celebrated team norms.

- Buddy System Program: Establish mentorship or work partnerships to create natural mutual assistance systems, reducing isolation and building strong social ties.

Study Limitations

Although this study provides comprehensive overview, certain limitations warrant acknowledgment. First, this documentary research may lack depth obtainable through interviews or direct behavioral observation in specific contexts. Second, this article primarily focuses upon dyadic relationships between leaders and members, potentially not encompassing group-level factors or organizational culture that may indirectly impact OCB.

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A Comparative Analysis of Software Quality and Development Cost for a Community Elderly Database System A Case Study Comparing Four Development Approaches Using the Personal Software Process (PSP)

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Abstract

As Thailand fully transitions into an aging society, the development of information technology to support elderly care has become essential, particularly for safety-critical functions such as location tracking and emergency alerts. This research aims to analyze and compare software quality and development costs using the Personal Software Process (PSP) framework. The study compares four development approaches: (G1) Solo Waterfall, (G2) Pair Programming, (G3) Code Review, and (G4) Test-Driven Development (TDD). The experiment involved third-year software engineering students developing three core functions: health record management, Google Map location tracking, and emergency help requests, utilizing tools such as Express JS, MySQL, Mocha, and Chai.

Empirical results indicate that G4 (TDD) achieved the highest software quality, with a Defect Removal Efficiency (DRE) of 100% in critical functions and the lowest Defect Density (12.93-22.73 per KLOC), despite higher initial time costs due to test case development. Conversely, G1 (Waterfall) exhibited the lowest initial labor cost (1,585 THB) but recorded the highest post-run defects, leading to significant long-term hidden costs. G2 recorded the highest human resource costs as it required two developers for a single task. The suitability analysis concludes that TDD and Code Review are the most

appropriate approaches for safety-critical systems to ensure data integrity and the life safety of the elderly.

Keywords: Software Quality, Development Cost, Personal Software Process (PSP), Aging Society, TDD

Background and Statement of the problem

At present, Thai society has fully transitioned into an aged society. According to the report on the situation of the elderly in Thailand, the proportion of the population aged 60 and over is continuously increasing, marking Thailand's entry into a complete aged society. Consequently, the government and local administrative organizations must prepare service systems and data management to systematically support elderly care at the community level (Department of Older Persons, 2024). Specifically, the application of information technology is crucial to support efficient and timely monitoring, care, and assistance for the elderly.

Furthermore, such systems involve the collection and processing of health and personal data, requiring high levels of data accuracy and information security. Several software development process research papers indicate that software with numerous defects often leads to long-term hidden costs, including maintenance expenses, bug fixes, or risks to user trust—particularly in systems related to human safety.

However, software development for government agencies or local administrative organizations in the Thai context often faces budget and human resource constraints. As a result, many projects opt for traditional software development processes, such as the Waterfall model. Although it offers low initial costs and ease of planning, software engineering research suggests that this process may lead to high Costs of Quality (CoQ) in the later stages. This is because defects are typically detected toward the end of the project, causing the cost of remediation to increase significantly.

Over the past decade, the Personal Software Process (PSP), developed by Watts S. Humphrey, has been recognized in the software engineering field as a personal-level development framework that focuses on systematic planning, tracking, and quality control (Humphrey, 1995; 2005). PSP emphasizes managing the developer's workflow at

each stage—from estimation and design to coding, testing, and result review. Recent studies, such as those by Mansoor et al. (2017) and López-Martín et al. (2017), indicate that implementing PSP fosters development discipline, reduces errors caused by uncontrolled workflows, and supports the development of higher-quality software under time and resource constraints.

Additionally, recent trends in software process research reflect that PSP can be appropriately applied alongside various development methodologies and is not limited to traditional processes. Applying PSP in this manner strengthens the systematic approach of developers and supports early defect reduction, which significantly decreases the burden of late-stage troubleshooting. This concept aligns with software development for an aged society, which requires systems that are accurate, reliable, and capable of cost management within the constraints of government agencies and communities.

Accordingly, this research utilizes the Personal Software Process (PSP) as a framework for empirical data collection to compare four software development models: (1) Individual Waterfall development, (2) Pair Programming, (3) Team Code Review, and (4) Test-Driven Development (TDD). The evaluation is conducted through key performance indicators, namely Defect Removal Efficiency (DRE), Review Yield, and Cost of Quality (CoQ).

To enhance modernity and alignment with the nature of elderly care systems, this research also incorporates security defect auditing alongside functional defect tracking, as the system involves the storage of personal data and location coordinates. The development utilizes standard tools, including Express.js and MySQL, with Mocha and Chai for automated testing. The resulting analysis is expected to serve as academic data to support decision-making in selecting the most cost-effective software development process for community-level aged society software projects and to provide a reference guideline for government agencies in the future.

Objectives

1. To analyze and compare the software quality and development costs of a community-based elderly database system across different software development models, utilizing empirical metrics based on the Personal Software Process (PSP) framework.

2. To evaluate the efficiency of software defect prevention and removal, covering both functional defects and security vulnerabilities, by assessing Defect Removal Efficiency (DRE) and data integrity metrics.

3. To analyze the cost-effectiveness and suitability of various software development models in order to propose academic guidelines for selecting optimal software development processes for aged-society software projects within the context of government agencies and local communities.

Expected benefits

This research is expected to yield significant contributions in both academic and practical dimensions, as follows:

1. Academic Contributions: The study will generate a specialized body of knowledge regarding the correlations between software development processes, software quality, and development costs within the specific context of aged-society software. This will serve as a foundational academic reference for future software engineering research.

2. Practical Application and Implementation: The research findings will provide a definitive guideline for selecting appropriate software development methodologies for mission-critical systems operating under the budgetary and resource constraints typical of government agencies and local communities.

3. Security and Human Resource Development: The research promotes the development of highly accurate and reliable software while fostering quality control discipline and systematic development skills among software practitioners.

Conceptual Framework

1. Theoretical Framework and Research Concepts

This research integrates core Software Engineering principles to establish an academic framework for evaluating software quality and development costs, detailed as follows:

1.1 Personal Software Process (PSP)

The Personal Software Process (PSP) serves as the primary conceptual framework for systematic empirical data collection at the individual developer level. PSP

emphasizes the measurement, analysis, and quality improvement of software development by recording real-world data throughout the development lifecycle, including time, effort, and defects. This enables software engineers to control and enhance both quality and cost through a verifiable academic approach, as defined in the Personal Software Process Body of Knowledge (PSP BOK) (Pomeroy-Huff et al., 2009).

To evaluate process effectiveness, this study utilizes key metrics aligned with the PSP framework:

- Defect Removal Efficiency (DRE): Reflects the process's ability to detect and resolve errors before system delivery.
- Review Yield: Represents the proportion of defects discovered during the review phase prior to compilation or testing.
- Cost of Quality (COQ): Evaluated by the ratio of time spent on Prevention and Appraisal activities compared to the time spent on Failure (rework).

1.2 Software Development Approaches

The research employs four primary software development methodologies as independent variables:

- Waterfall (Solo Development)
- Pair Programming
- Team Code Review
- Test-Driven Development (TDD)

Each approach possesses distinct quality control characteristics. This study aims to compare the outcomes of each model under the same PSP measurement framework to provide a concrete analysis of differences in quality and cost.

1.3 System Criticality

The case study system is categorized as a Safety-Critical System, as it involves elderly data and services directly impacting user safety and well-being. This includes high-reliability functions such as location tracking and geocoding via map services. Furthermore, the Data Integrity of health records is a vital component of system criticality in this context.

1.4 Data Security

This research considers data security in conjunction with Functional Quality. It analyzes Security Defects occurring during development, such as access control management for sensitive personal and health data. Integrating security into the PSP framework allows for a comprehensive evaluation of system quality from both technical and ethical perspectives.

2. Research Framework

The research framework focuses on studying the impact of different software development models on quality and development costs.

2.1 Independent Variables: Four experimental groups:

- G1: Waterfall (Solo Development)
- G2: Pair Programming
- G3: Team Code Review
- G4: Test-Driven Development (TDD)

2.2 Dependent Variables (Quality): The number and types of Defects detected at each development stage and the functional accuracy of high-criticality features.

2.3 Dependent Variables (Cost Outcomes): Development Time and Effort (Man-hours) expended within each model.

Experimental Context: The system is developed by third-year Software Engineering students with similar programming and design backgrounds to control for the confounding variable of developer experience.

3. Research Hypotheses

The researcher has established the following comparative hypotheses:

Table 1: Comparative Hypotheses Across the Four Experimental Groups

Experimental Group	Software Quality Hypothesis	Cost/Effort Hypothesis
G1: Waterfall	Highest number of defects found Post-run.	Lowest cost in terms of Man-hours.
G2: Pair Programming	High defect reduction capability from the start of the coding process.	High cost due to utilizing two human resources for a single task.
G3: Code Review	Highly effective at detecting Pre-run errors.	Moderate cost, with increased time allocated to the review phase.
G4: TDD	Highest code quality with minimal bugs.	High initial cost due to the Learning Curve of writing test suites.

Based on the comparative hypotheses of the four experimental groups, it is evident that the differing software development approaches significantly impact both software quality and development cost/time. Group G1 (Waterfall) tends to encounter a high volume of post-run defects, despite having the lowest cost in terms of man-hours. Conversely, Group G2 (Pair Programming) and Group G3 (Code Review) demonstrate the capability to mitigate errors during the pre-run phase, albeit at the expense of varying levels of increased costs.

Group G4 (Test-Driven Development: TDD) is projected to yield the highest software quality with the fewest defects, as testing is integrated from the very beginning of the development process. However, the TDD approach incurs higher initial costs and time requirements due to the learning curve associated with the methodology. Collectively, these hypotheses clearly reflect a trade-off relationship between software quality and the development cost/effort required by each respective development model.

Research Methodology

This study is an experimental research designed to compare the software quality and development costs of an elderly database system under the framework of the Personal Software Process (PSP). The operational details are as follows:

1. Participants and Background

The sample group consists of 10 third-year Software Engineering students who have successfully completed relevant foundational courses, including Computer Programming, Object-Oriented Programming, and Object-Oriented Analysis and Design. The participants were purposively selected and divided into four experimental groups as follows: G1 (n=2), G2 (2 pairs, n=4), G3 (n=2), and G4 (n=2). This ensures the participants possess the necessary readiness to develop software characterized by high complexity and criticality, specifically regarding data accuracy, system reliability, and security.

2. Experimental Groups

The researcher divided the 10 participants into four experimental groups to compare the outcomes of the different development processes. Each group performed their assigned tasks under the systematic data collection framework of the PSP. The distribution of participants is as follows:

Group G1: Individual Waterfall development (Solo), consisting of 2 participants working independently as a baseline for cost and defects.

Group G2: Pair Programming, consisting of 2 pairs (4 participants total) to study the impact of collaborative coding on defect reduction.

Group G3: Development utilizing the Code Review process, consisting of 2 participants to measure the efficiency of peer verification and Review Yield.

Group G4: Test-Driven Development (TDD), consisting of 2 participants focusing on high-quality code through pre-coding test case development.

3. Measurement and Scope

The evaluation utilizes identical criteria across all groups. Software quality is assessed based on the number of Defects, Defect Removal Efficiency (DRE), and Security Defect audits. Development costs are measured through Development Time and the Cost of Quality (COQ) to reflect the overall cost-effectiveness of the software development process.

4. Development and Testing Tools

System development utilizes Express.js as the primary backend framework and MySQL as the database management system for storing personal data, health records, and location coordinates. Software testing is conducted using Mocha and Chai to support automated testing, software quality data collection, and the measurement of key metrics according to the PSP framework.

5. System Functions for Data Collection

The researcher mandated that all four experimental groups develop software covering three core functions, each with varying levels of importance and criticality:

(1) Elderly & Health Data Management: This encompasses the recording, editing, and retrieval of personal and health data. The focus is on evaluating data accuracy, database schema consistency, and security defect auditing regarding data access through the MySQL management system.

(2) Google Maps Location Tracking: This function requires high precision and reliability. The researcher utilizes this function to collect data on the number of defects arising from calculation logic, coordinate management, and integration with external services, reflecting software quality in scenarios where data discrepancy poses a risk.

(3) Emergency Help Requests: This is the most critical function, as it directly impacts user safety and life. This function is employed to evaluate Defect Removal Efficiency by utilizing DRE and Review Yield metrics to compare the capability of each development approach in identifying and eliminating errors at an early stage, prior to actual system deployment.

Research Results

Based on the empirical data analysis following the Personal Software Process (PSP), the research findings and discoveries corresponding to the objectives and hypotheses are reported as follows:

Table 2: Empirical Results Based on the Personal Software Process (PSP)

Function	Group	LOC	Time (Min)	PD	Defects Found		Defect Density	DRE (%)
					Pre-Compile	Post-Compile		
1. Elderly Data Management	G1	134.50	126.89	1.06	2.01	11.04	97.01	15.38
	G2	138.25	98.05	1.41	6.01	7.01	94.20	46.15
	G3	108.50	144.67	0.75	7.03	2.01	83.33	77.78
	G4	232.50	169.71	1.37	3.01	0.00	12.93	100.00
2. Google Maps Tracking	G1	82.50	93.75	0.88	2.01	17.10	231.71	10.53
	G2	94.25	114.94	0.82	5.01	5.01	106.38	50.00
	G3	86.50	133.08	0.65	5.03	3.02	93.02	62.50
	G4	132.50	179.05	0.74	2.01	1.00	22.73	66.67
3. Emergency Help Requests	G1	55.50	99.11	0.56	2.02	7.06	163.64	22.22
	G2	54.25	87.50	0.62	3.01	2.01	92.59	60.00
	G3	72.50	127.19	0.57	3.02	1.01	55.56	75.00
	G4	111.50	168.94	0.66	2.01	0.00	18.02	100.00

Note: The data presented in Table 2 (LOC, Time, and Defects) represent the Average (Mean) values calculated from each experimental group.

Description of Key Research Metrics

The researcher utilized primary metrics from the Personal Software Process (PSP) as performance indicators. The definitions and formulas are as follows:

1. Productivity (PD): The rate of software production relative to time, measured in LOC/Min. It compares the cost-effectiveness of time resources across experimental groups.

$$Productivity = \frac{Lines\ of\ Code(LOC)}{\text{Development Time (Minutes)}}$$

2. Defect Density (DD): The ratio of defects found per unit of software created, serving as an indicator of code "cleanliness" and quality. A lower DD signifies reduced operational risk, which is critical for high-criticality functions.

$$\text{Defect Density} = \left(\frac{\text{Total Defects}}{\text{Lines of Code}}\right) \times 1{,}000$$

Note: The multiplier of 1,000 is a standard software engineering convention for easier comparison.

3. Defect Removal Efficiency (DRE%): The ability of the development process to detect and resolve errors before system execution (pre-compile). It measures how effectively an approach prevents errors from reaching the end-user, thereby reducing Hidden Costs.

$$\text{DRE\%} = \left(\frac{\text{Pre} - \text{Compile Defects}}{(\text{Pre Compile Defects} + \text{Post Compile Defects})}\right) * 100$$

Analysis of Findings

1. Comparison of Quality and Cost

Group G1 (Waterfall) exhibited the lowest DRE% across all functions (reaching a minimum of 10.53% in the Google Maps function) and the highest Defect Density (DD) of 231.71 in the tracking function. This aligns with the hypothesis that this method encounters the most errors post-run. Conversely, Group G4 (TDD) demonstrated significantly superior quality, achieving a DRE% of 100% in data management and emergency requests. Although its Productivity (PD) was not markedly higher than other groups, it

resulted in the lowest Defect Density (12.93-22.73), validating the hypothesis regarding peak quality.

2. Efficiency in Critical Functions and Data Integrity

In the Google Maps Location Tracking function, which requires High Reliability, Group G4 (TDD) and Group G3 (Code Review) successfully maintained a DD below 100, while G1 and G2 showed significantly higher error density. Regarding Data Integrity and security, G4 detected all defects via Mocha and Chai before delivery, resulting in zero leakage of defects in health record management.

3. Cost-Effectiveness and Suitability Analysis

Although Group G2 (Pair Programming) achieved the highest PD in the first function (1.41 LOC/Min), the total cost-effectiveness is lower when considering the two-person requirement compared to G3 or G4, which achieved higher DRE% with a single developer. For aged-society software where safety is paramount, TDD (G4) offers the highest Value for Money in the long term by mitigating life-threatening defect risks.

4. Behavioral and Learning Outcomes

Empirical evidence suggests that participants utilizing PSP alongside modern tools significantly reduced final-stage errors when adopting Code Review or TDD approaches.

In addition to quality metrics, Development Cost Analysis and cost-effectiveness are vital components that complete the overall picture of this research. The researcher established a labor rate for software development at 300 THB per hour (or 5 THB per minute). Actual time spent developing the three core functions was used to calculate the total development cost for each experimental group based on their respective work models. These calculations facilitate a comparative analysis of the relationship between development processes, software quality, and cost-effectiveness, as presented in the following table:

Table 3: System Development Costs

Group	Development Model	Total Time (3 Functions)	Number of Developers	Total Labor Cost (THB)
G1	Waterfall (Solo)	317 Min.	1	1,585
G2	Pair Programming	300 Min.	2	3,000
G3	Code Review	402 Min.	1	2,010
G4	TDD	516 Min.	1	2,580

Analysis of Development Costs

Table 3 provides a comparison of the development costs for the elderly database system across the four experimental groups, highlighted by the following points:

1. Lowest Initial Cost (G1: Waterfall)

Group G1 incurred the lowest labor cost at 1,585 THB, validating the hypothesis that individual Waterfall development is cost-efficient regarding man-hours. However, considering the high volume of post-compile defects (35 total: 11+17+7), this group faces the highest risk of significant Hidden Costs for maintenance and rework in the future.

2. Highest Human Resource Cost (G2: Pair Programming)

While Group G2 recorded the lowest development time per function (300 minutes total), the requirement for two developers working simultaneously resulted in a doubled labor cost of 3,000 THB. This represents the highest cost in this experiment, consistent with the initial hypothesis.

3. Investing in Quality and Value (G4: TDD and G3: Code Review)

Group G4 (TDD) incurred a cost of 2,580 THB, higher than G1 and G3 due to the learning curve and the additional time required to develop test suites. However, in terms of Value for Money, this method provides the highest quality with only one defect escaping to the post-run phase, thereby drastically reducing long-term failure costs. G3 (Code Review) offers a strategic balance; with only a marginal cost increase over G1 (2,010 THB), it significantly improves Defect Removal Efficiency (DRE).

4. Cost of Quality (COQ)

Analysis Aligned with the PSP framework, this research demonstrates that increasing the time allocated to Prevention and Appraisal activities (as seen in G3 and G4) effectively manages high-criticality systems, such as location tracking and health records, despite the higher initial investment.

Summary of the Study

Based on the comparative analysis of the four development models (G1–G4) across three system functions with varying levels of criticality, the key findings of this study are concluded as follows:

1. Software Quality and Reliability Group G4 (TDD) yielded the highest quality results, demonstrating the lowest Defect Density across all functions (ranging from 12.93 to 22.73 per KLOC). Furthermore, it achieved a DRE of 100% in the Data Management and Emergency Help Request functions, indicating that no defects leaked into the actual execution phase. In contrast, Group G1 (Waterfall) exhibited the lowest quality, recording the highest number of post-compile defects in every function, particularly in the Google Maps tracking function, where the DRE was as low as 10.53%.

2. Development Cost and Effort As hypothesized, Group G1 incurred the lowest initial labor costs; however, it carries a significant risk of high hidden costs due to the extensive rework required to fix numerous post-development defects. Group G2 (Pair Programming) presented the highest human resource costs, as it utilizes two developers for a single task, even though it reduces defects more effectively than the traditional method. While Group G4 (TDD) required a higher initial time investment for writing test suites, it offers the highest long-term cost-effectiveness for safety-critical systems.

3. Suitability Analysis For functions directly impacting human safety—such as Location Tracking and Emergency Help Requests—the TDD (G4) and Code Review (G3) models are the most suitable. These approaches provide the high reliability and data integrity necessary for mission-critical community applications, ensuring that the system remains accurate and trustworthy under high-risk scenarios.

Discussions

The analysis of the empirical data collected through the Personal Software Process (PSP) for the development of the elderly database system yields the following points of discussion:

1. Software Quality and Defect Removal Efficiency

The findings clearly demonstrate that Group G4, utilizing Test-Driven Development (TDD), produced the highest quality software, achieving a Defect Removal

Efficiency (DRE) of 100% in key functions, specifically Elderly Data Management and Emergency Help Requests. This outcome aligns with the theories of Humphrey (1995, 2005), which posit that PSP is a process centered on early defect prevention through systematic planning, inspection, and personal-level measurement. Furthermore, it supports the PSP Body of Knowledge (Pomeroy-Huff et al., 2009), which highlights that structured quality assurance prior to coding and phased testing significantly enhances defect removal capabilities.

2. Balancing Cost and Quality

When evaluating the dimensions of cost alongside software quality, Group G1—despite having the lowest initial labor costs—encountered a high volume of late-stage defects. This led to significant hidden costs in maintenance, rework, and a reduction in overall system reliability. This observation is consistent with Humphrey (2005) and Pomeroy-Huff et al. (2009), who suggest that the true cost of software should be measured through the Cost of Quality (COQ) rather than initial development expenses alone. Regarding Group G2 (Pair Programming), while it reduced defects more effectively than G1, it required doubling human resource costs. This mirrors the findings of Mansoor et al. (2017), which suggest that while increased human resources can reduce errors to an extent, they cannot fully replace structured inspection processes like PSP or TDD. These findings reinforce the concept that early investment in quality assurance yields superior long-term returns.

3. Suitability in the Context of Safety-Critical Systems

The results for functions directly related to safety, such as Location Tracking and Emergency Help Requests, confirm that TDD (G4) and Code Review (G3) are the most appropriate methodologies for such systems. Conducting Security Defect audits during the development phase further strengthens confidence in protecting sensitive elderly health data. This is in accordance with the Department of Older Persons (2024), which emphasizes the necessity for secure and reliable information systems to support Thailand's rapidly expanding aged society. These security considerations are inherently linked back to the long-term quality and cost-effectiveness of the system.

4. Impact on Personnel Development and Professional Standards

The application of the PSP framework to third-year students with foundations in programming and Object-Oriented Design shows that training within this framework fosters systematic software quality control skills. This is consistent with studies by Mansoor et al. (2017) and López-Martín et al. (2017), which found that integrating PSP into academic curricula elevates students' abilities in planning, inspection, and performance evaluation through concrete metrics. Moreover, the PSP Body of Knowledge (2009) identifies developer discipline in recording and analyzing personal work data as a cornerstone for raising professional standards. The findings suggest that integrating PSP into software engineering education can serve as a blueprint for establishing development standards for local government agencies, particularly for systems affecting the health and quality of life of the elderly, aligning with Thailand's current social and policy context.

Due to the small sample size per group (n=1 or 2 units per group), this study is identified as a preliminary empirical case study. While the findings provide significant insights into the PSP process, they represent initial empirical evidence within a controlled academic environment.

Recommendations

1. Policy and Practical Implications

The findings of this research can serve as a strategic guideline for establishing policies and procurement requirements for software development within government agencies and local administrative organizations. For high-criticality systems involving sensitive personal data, it is recommended that development mandates include quality-centric processes, such as Test-Driven Development (TDD) or Code Review, to mitigate security risks and system failures. Furthermore, budgetary planning should shift toward evaluating the Total Cost of Ownership (TCO) rather than focusing solely on initial development costs. This holistic approach will help organizations avoid significant long-term hidden costs associated with maintenance and error remediation.

2. Directions for Future Research

Future studies should extend the scope of analysis to investigate long-term hidden costs, specifically focusing on maintenance expenditures and the socio-economic risks arising from system failures. Additionally, future research could incorporate deeper security assessments, such as Penetration Testing (Pentest), to ensure robust data protection. Expanding the research context to other platforms, such as mobile applications specifically designed for the elderly, would also enhance the comprehensiveness and practical relevance of the findings in real-world scenarios.

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Enhancing Business English Conversation Ability by Using Simulation Scenarios for Bachelor Degree Students at North Bangkok University

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Abstract

The objectives of this research were (1) to compare Business English conversation ability by using simulations scenarios for bachelor degree students at North Bangkok University before and after learning by using simulation scenarios, and (2) to assess students' satisfaction with learning Business English by using simulation scenarios. The sample used in this research consisted of 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University selected by using a purposive sampling method. The research instrument used was: (1) Learning management plan for learning Business English conversation by using simulation scenarios; (2) Business English conversation proficiency test; and (3) Student satisfaction assessment form for learning Business English by using simulation scenarios. Statistics used for data analysis included percentage, mean, standard deviation, and t-test. The experiment was conducted using an experimental design by quasi- experimental, one group pre-test – post-test. The research period will be during the second semester of the 2025 academic year, from October 28, 2025 to January 6, 2026, for a total of 10 weeks, with 3 hours per week, amounting to 30 hours.

The research results revealed that (1) the Business English conversational ability of bachelor degree students at North Bangkok University after learning by using simulations scenarios was significantly higher than their pre-learning ability at the .05 level. (2) The students were highly satisfied (X = 4.12) with learning Business English using simulations scenarios and the post-test mean scores (21.37) higher than the pre-test score (16.13).

Keywords: Simulation Scenarios, Business English Conversation Ability, Satisfaction with learning Business English

Background and Statement of the problem

English is the world's universal language, playing a crucial role in international communication in all areas, including education, cultural exchange, trade and economics, medicine, politics, logistic and tourism. In today's society, we are in the era of information and technology. The world is growing rapidly and changing. At the same time, the level of competition in professional careers is increasing exponentially. English has become increasingly important and has become a key factor in daily life and a factor in future employment. This is evident in the selection process for individuals in each organization, whether public or private, using various English language proficiency tests, such as written exams or interviews conducted in English.

The Ministry of Education recognizes the importance of English and has organized English as a second language for students. This aims to equip Thai youth with the knowledge, understanding, and the ability to use English for daily communication with foreigners and to cope with the competitive market in the future. However, actual conditions and measurement of English language achievement have shown that English language learning levels are below standard, even though there are teachers who have completed their education in the relevant subject and foreign teachers teach English. In Thailand, Thai students have more opportunities to study English with native speakers. English study hours have been increased, but the English learning achievement has not reached the target. Considering the problems of Thai students' English learning, it is found that they lack all aspects of English learning, including reading and writing. However, the most obvious empirical problem is English conversation. Students are unable to apply their English knowledge from the classroom to real-life situations. Students lack confidence and are almost always nervous when faced with using English in real-life situations. (Chunponganich, 2021).

When considering the reasons for the lack of success in English conversation, there are two main causes. First, English teachers lack experience in creating an English classroom that is a language-based classroom. They still rely primarily on textbook content and teach according to the content in the English textbooks, which sometimes involve topics that are far from their own. Students are unable to fully understand the

content being taught, leading to students not being as interested in learning English as they should be.

The second issue is that the learning activities lack variety and do not focus on creating authentic language experiences for learners. Finally, the learners themselves lack confidence and experience anxiety every time they have to speak English, even with just a short, simple sentence. This is consistent with Lan et al. (2025) studies about From Role-play to Virtual Reality: A Review of Simulation in English Language Teaching stated that Globalization, digitalization, and the post-pandemic shift toward online and blended education have reshaped the field of Teaching English to Speakers of Other Languages (TESOL). These changes highlight the need for approaches that not only develop linguistic competence but also foster communication, collaboration, and intercultural skills. Simulation has attracted growing attention in this context because it offers authentic, experiential learning environments that align with communicative and experiential learning theories. Recent studies have shown that simulation can improve learners' speaking, listening, motivation, and critical thinking, while also supporting teachers in adopting more innovative pedagogies. However, the research landscape remains uneven. Existing studies are largely small-scale and short-term, focusing mainly on immediate language gains. Critical areas remain underexplored, including learner differences, cross-cultural adaptability, integration with assessment, and the potential of emerging technologies such as virtual and augmented reality. These gaps limit both the generalizability of findings and the theoretical development of simulation-based TESOL. This review draws on studies indexed in the Web of Science to synthesize current evidence, identify limitations, and highlight emerging directions. Unlike earlier reviews, it situates simulation within wider educational and societal trends, offering a clearer rationale for its relevance and providing a roadmap for sustainable and innovative practices in TESOL. This is consistent with the research study of Luara and Carbonell (2019) about developing English Speaking Skills Through Simulation-Based Instruction stated that Foreign language teachers and researchers face a major challenge enabling students' learning. Not only must they provide training in the target language, but they must also find ways to optimize class time and enhance students' communication skills in the target language. How does technology intersect with English teaching in ways that

benefit learning a possible approach would align with integrating web-based strategies and optimizing class time through new methodologies, techniques and resources. In this study, a group of university engineering students were taught with simulations to aid their learning of English as a foreign language. These engineering students were taught English through both class-based and a large-scale real-time web-based simulation. They present the results of quantitative analysis of students' oral production. The goal was to show whether simulation-based instruction contributes to significant progress in oral language production in English. The results indicate that students progressed significantly in four language-related areas: vocabulary, pronunciation, variety of expression and grammar. Also this is consistent with the research study of Abdualhussein et al. (2024) about using simulation in developing the learning of English as a foreign language stated that throughout the years, preparing the individuals for a demanding life and providing the society with socially and intellectually mature citizens have been one of the most important missions of schooling. Assuming this noble mission, educators have sought ways to fulfill the individual's need of being proficient enough to cope with the challenges of the world. In order to achieve this end, through the behaviorist reign, the learner has been regarded as a passive member of the classroom which is shaped by the holy dominance of the omnipotent instructor. But things have turned to a new dimension – the teacher is no longer "the sage on the stage" but the silent overseer in the back. Modern methodology fosters a shift from teacher-centered to student-centered and even student-generated approaches, leaving enough space for maneuver to the individual learner and laying emphasis on the power of self-instruction and responsibility for learning. The greatest emphasis of the instructional act should be placed on the students' exploration of their own attitudes and values. The practical part of this article will explore in detail the theoretical and the empirical dimensions of one of the most important basic active learning activities – simulations.

Business English is crucial in logistics to ensure seamless, cross-border communication, manage international supply chains, and interpret critical documents like bills of lading and customs forms. Low proficiency causes miscommunication, operational delays, and increased costs. Mastery enhances career opportunities and improves operational efficiency. Bachelor Degree of Business Administration Program

Students in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University lacked communication skills in various situations described in textbooks. This was due to a lack of experience in such scenarios, preventing students from communicating accurately and effectively. Therefore, the researcher created simulated scenarios aligned with the chosen content and developed a lesson plan to help students understand the situations and practice their communication skills in these simulated scenarios. To enable students to understand communication in given simulated situations and to practice communicating effectively and make learning English fun more challenging.

From a study of documents and research to find solutions to the problem of students' inability to apply the English knowledge they have learned in the classroom to real-life conversations, it was found that the solution should involve organizing teaching and learning activities that directly create language experiences for students, emphasizing language practice. Real-world language use should be used to simulate classroom conversations to create an atmosphere that stimulates interest and encourages students to converse more effectively. Given the importance of English in today's world, a study of the current problems, main causes, and solutions to address students' inability to apply English in real-life situations was conducted. The researcher aimed to address this issue and provide guidelines Lesson Plan for teaching to enhance Business English conversational ability by using simulations Scenarios for bachelor degree students at North Bangkok University in Pathum Thani Province during the second semester of the 2025 academic year. Furthermore, English language teachers can utilize the research findings to develop their English language curriculum by using simulations, and it can help English language administrators formulate policies for managing English language instruction and improving current English language teaching practices.

Objective

1. To compare Business English conversation ability by using simulations scenarios for bachelor degree students at North Bangkok University before and after learning by using simulation scenarios

2. To assess students' satisfaction with learning Business English by using simulation scenarios.

Expected benefits

1. Teaching activities using simulation scenarios can enhance the English conversational ability of Bachelor degree students at a North Bangkok University.

2. Students are satisfied with the Business English learning using simulation scenarios, and have increased confidence in using English. They are also more likely to use English in real-life conversations.

3. Guidelines for teaching simulation situations with other students are developed.

Conceptual Framework

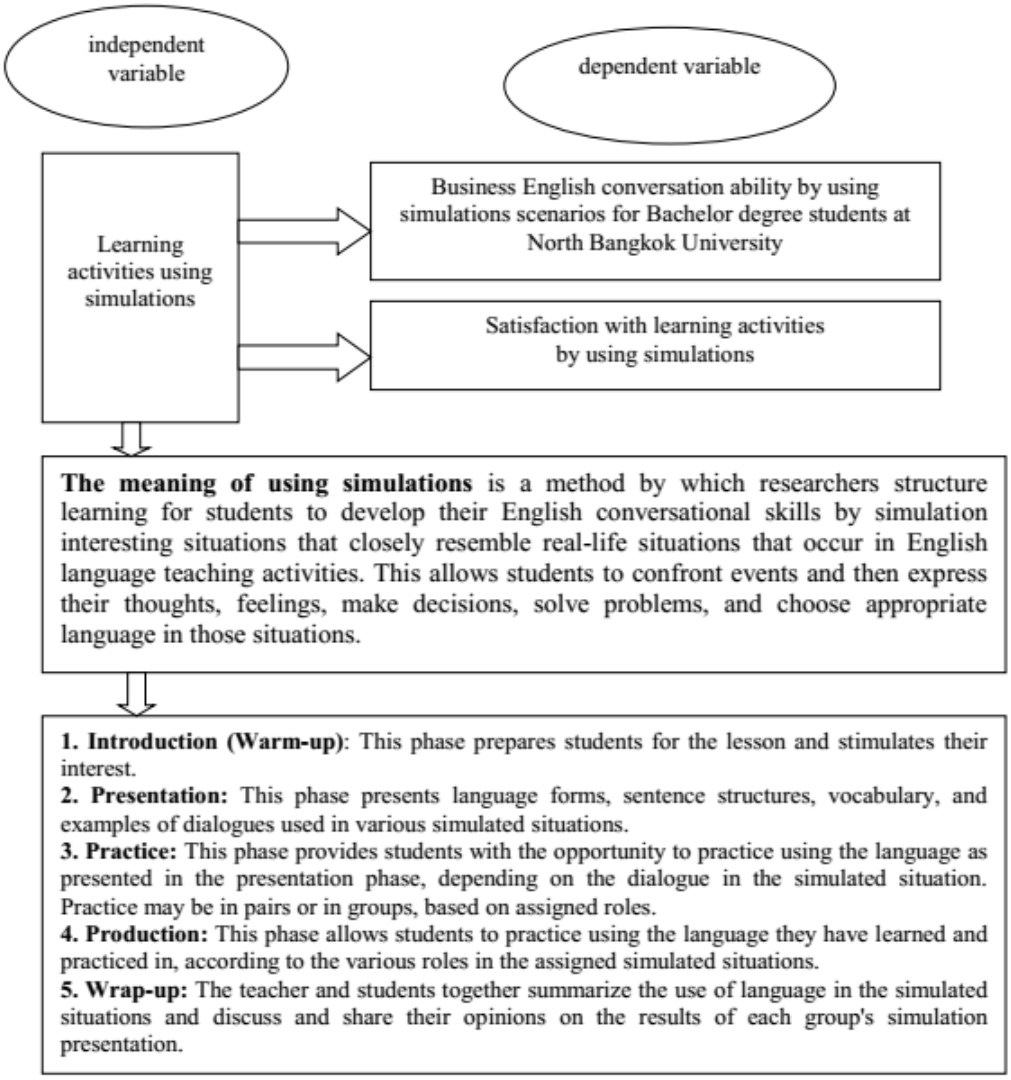


Figure 1 Conceptual Framework

Research Methodology

Research design

This research utilized a quasi-experimental design. The researcher conducted the experiment using a One Group Pretest-Posttest Design (Tarhan et al., 2020)

Group	Pre-Test	Experiment	Post-Test
E	T1	X	T2

T1 stands for Pre-Test

T2 stands for Post-Test

E stands for Experimental Group

X stands for Simulation-Based Learning

1. The researcher as an instructor who taught the students who studied the subject ENG311 (Business English). There were 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University that were the sample group for this study, conducted a pre-experimental English conversational proficiency test using a test.

The students selected one of five simulated situations by drawing lots. The students then paired up with a partner, voluntarily choosing roles based on their interests. The students were then scored according to a set of criteria. The scores of the researcher were calculated and recorded before the experiment.

2. Implement five simulation-based learning plans with the selected sample group for a total of 30 hours.

3. Test students' English conversational ability after the experiment with a post-experiment English conversational ability test. Each group of students draws a random number again to select a simulation topic, but parallel to the pre-experiment English conversational ability test, and records their scores after the experiment.

4. The researcher distributed a questionnaire to measure students' satisfaction with learning English using the simulation to assess their level of satisfaction.

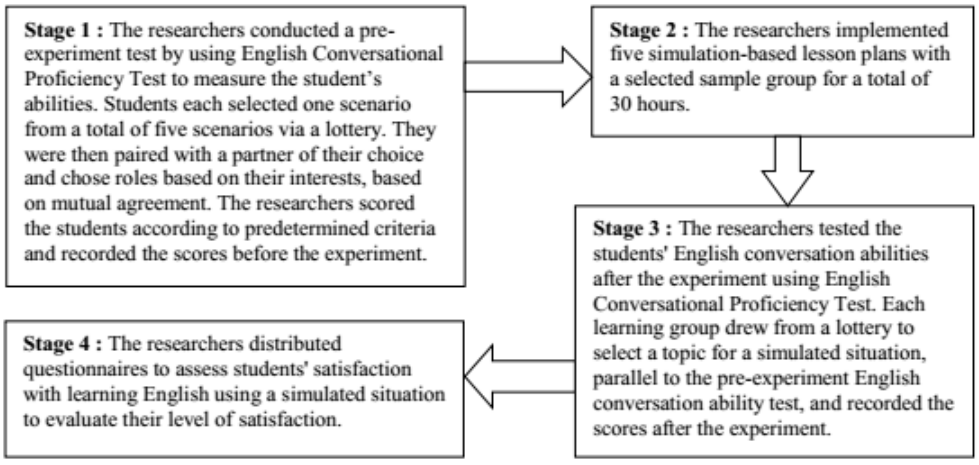


Figure 2 Research Process

Population and Sample

1. Population: The population used in this research were 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University.

2. Sample: The sample group used in this research were 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University. The sample group was obtained through purposive sampling.

Research Tools

1. Tools used in the experiment include lesson plans using simulations, to develop English conversation skills. Five plans were created using the following steps:

1.1 Study the course description for ENG311 (Business English) from the Global Business English Curriculum, Liberal Arts faculty, North Bangkok University. And studied standards for learning foreign languages, and examined activities and skills in teaching communicative English from Cambridge Business Plus book; Student's book (Helliwell, 2014)

1.2 Study the theories and principles of learning management using simulations from relevant documents and research.

1.3 Select simulated scenarios that are interesting and relevant to the students, specifically business situations that students will encounter in their future careers and daily lives related to business communication. The researchers therefore created dialogues used in the research about simulated business communication situations to give students the opportunity to practice using English language before using it in real life. There were a total of 5 simulated situations created, as follows:

Scenarios 1: Welcome to our company

Scenarios 2: Business Communication

Scenarios 3: Products and Services

Scenarios 4: Targeting the Customer

Scenarios 5: Achievements

1.4 Create 10 Business English conversation lesson plans using Simulation Scenarios, each lasting three hours.

1.5 Finding content validity of lesson plans involves ensuring the planned objectives, materials, activities, and assessments accurately align with the curriculum standards. This is best achieved through expert review, systematic mapping (using a table of specifications), and calculating validity indices to ensure the plan adequately covers the intended learning domain. Using steps to determine content validity of lesson plans as following

1.5.1 Define Content Domain: Clearly outline the learning goals, standards, and key topics that the lesson plan must cover.

1.5.2 Establish a Table of Specifications (Blueprint): Map lesson activities, learning materials, and assessments against these learning objectives to ensure all topics are represented proportionally.

1.6 Expert Panel Review (Subject Matter Experts): The researchers established a panel of experts, consisting of three university professors with expertise in curriculum development, linguistics, and English, holding associate professorships, to help determine the Content Validity of the Lesson Plan.

They were asked to evaluate each item (e.g., learning objectives, teaching materials, activities, assessments) as relevant and accurate. A scoring scale was used, such as: (1) Not relevant (2) Somewhat relevant (3) Fairly relevant (4) Very relevant

1.7 After experts reviewed and evaluated 10 Business English conversation lesson plans using Simulation Scenarios, they found them to be very relevant. Therefore, the researchers were able to use these lesson plans to teach the sample group.

2. The data collection tools included an English Conversation Proficiency test, and a satisfaction evaluation form regarding the simulated situation. The guidelines for creating these tools are as follows:

2.1 English Conversation Proficiency Test

The researchers studied test design approaches from the Article "Testing in English Language Teaching and its Significance in EFL Contexts: A Theoretical Perspective" (Ali et al., 2019) to use as a guideline in creating the tests.

1. Study and analyze the Global Business English curriculum for design a framework for creating learning objectives that align with the learning standards set by the curriculum, in order to develop the tests.

2. Create one Pretest and Posttest to measure English conversation ability. Each test required students to engage in English conversation based on five simulated scenarios provided by the researcher. Students were paired voluntarily and selected one scenario by drawing lots, allowing them to choose their preferred role for the conversation.

3. The scoring criteria for English speaking ability were determined by adapting the criteria of The Foreign Service Institute Scale (FSI), The School Communicate Competence Scale, and The Bratz Scale (Nešić & Hamidović, 2022). These criteria measure six aspects of English conversational skills: accent, grammar, vocabulary, content, fluency, and acting. Each component is divided into five levels of ability. The total score is 30 points.

4. Methods for Determining the Quality of the English Conversational Proficiency Test: Before and after the experiment, the English conversational Proficiency Test and the developed scoring criteria were submitted to English language teaching experts 3 professionals with at least 10 years of experience in English, a Master's degree in Linguistics or English, and who hold academic positions as Associate Professor in the University for review of validity. For the test, the consistency of each simulated situation with the content and learning objectives was considered, using the following scoring criteria:

1 means the English Conversation Proficiency test is aligned with the content and learning objectives.

0 means unsure if the English Conversational Proficiency test aligns with the content and learning objectives.

-1 means the English Conversation Proficiency test is not aligned with the content and learning objectives.

Tests with a content validity index greater than or equal to 0.5 were then selected, indicating that the simulation had content validity (Kipli & Khairani, 2020).

2.2 Satisfaction Survey Regarding English Language Learning through Simulation Activities

This survey consists of 15 questions for students to choose from based on their feelings towards the simulation. It utilizes Likert Type Scale from Koo and S.W. (2025) satisfaction assessment framework to create a satisfaction survey regarding the use of simulations in English language learning. The researcher has defined the levels and interpretation of the satisfaction levels as follows:

Average score of 4.50-5.00 means Highest level of satisfaction.
Average score of 3.50-4.49 means Very satisfied
Average score of 2.50-3.49 means Moderately satisfied
Average score of 1.50-2.49 means Less satisfied
Average score of 1.00-1.49 means Lest satisfied

After the researcher completed the creation of both measurement tools, the researcher presented them to experts for further consideration. Revisions were then made based on the experts' suggestions to obtain the most effective versions of the English Conversation Proficiency measurement tool and the satisfaction assessment tool for use in the research.

Data collection.

The researchers conducted experiments and collected data on the development of English conversational skills and student satisfaction with learning activities using simulations among 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University selected by using a purposive sampling method., as follows:

1. A pilot of English Conversation Proficiency test was administered to students. The sample group consisted of 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the first semester of the 2025 academic year at North Bangkok University selected by using a purposive sampling method. This was done before the start of the simulated learning activities designed to enhance English conversation skills.

2. Implementing simulated learning activities, the teaching and learning process will be conducted according to the planned scenarios. Each learning plan will last 3 hours, with each session lasting 3 hours, totaling 30 hours, divided into 5 simulated scenarios. Students will learn about the various simulated scenarios and use English vocabulary, idioms, and sentence structures to create and practice conversations in class. In hours 1-3, students will learn about the characteristics of the given simulated scenarios, vocabulary, idioms, and English sentence structures. In hours 4-7, students will use the given scenario prompts to create English sentences and practice conversation with their classmates and chosen conversation partners. In hours 8-10, each pair of students will take a conversational practice exam. After the practice exam, a joint evaluation will be conducted to assess the strengths and weaknesses of the conversation, as well as their opinions and feelings about the various scenarios.

3. After completing all 30 hours of learning activities according to the learning plan created by the researcher, each pair of students will assess their English Conversational Proficiency using simulated situations. They will then be scored according to the established conversational criteria, and the pre-test and post-test scores will be compared to analyze the effectiveness of using simulated situational activities in enhancing English conversational skills.

4. Have students evaluate their satisfaction with the learning process using a simulation.

Data Analysis

The methods for data processing and analysis are as follows:

1. Analyze students' English conversational ability by comparing their abilities before and after the experiment. The scores from the pre-test and post-test administered by researcher, and the mean difference in scores was calculated using a dependent samples t-test.

2. Analyze student satisfaction by calculating the mean and percentage for each item based on the satisfaction assessment results regarding English language learning using simulated situations. Determine the ratio for satisfaction assessment as follows:

4.50-5.00 means Highest level of satisfaction

3.50-4.49 means High level of satisfaction

2.50-3.49 means Moderately satisfied

1.50-2.49 means Less satisfied

1.00-1.49 means Least satisfied

Research Results

Part 1: Analysis Results for the Study on Enhancing Business English Conversation Ability by Using Simulation Scenarios for Bachelor Degree Students at North Bangkok University

The English conversational ability of the learners before and after the experiment was assessed as follows:

A study of the scores obtained from the English Conversation Proficiency test before and after the experiment, using a dependent samples t-test to compare the difference in scores before and after the experiment, is shown in Table 1

Table 1 Comparison of English conversational ability using simulated scenario activities of learners before and after the experiment.

Testing	Number of Students	$\bar{X}$	$\bar{X}$ of the difference in scores	S.D. of the difference in scores	t
Before the experiment.	30	16.13	5.24	1.69	16.90*
After the experiment.	30	21.37			

*P = .05

Table 4.1 shows the mean scores of the English conversation ability test for 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University with a maximum score of 30 points. The mean score of the English conversation ability test before the experiment was 16.13, and the mean score of the English conversation ability test after the experiment was 21.37. A t-test revealed a statistically significant difference (P = .05) in the English conversation ability of the students

before and after the experiment. This indicates that the mean score after the experiment was higher than before the experiment. Therefore, role-playing activities helped students develop their English conversation ability.

Part 2: Results of the study on satisfaction with learning English using simulated situations.

The results of the student's satisfaction assessment regarding English language learning using simulations are presented in Table 3. The study examined the satisfaction assessment results after instruction aimed at enhancing English conversational skills using simulation activities. The mean percentage and interpretation of satisfaction levels are shown in Table 3

Table 2 Results of the study on satisfaction with learning English using simulation activities.

Message	Average score	Interpreting the results	Rating
1. The content used in the English conversation simulations is similar to situations in the students' real lives.	4.10	Highly	7
2. The content used in the simulations is coherent, interesting, and motivates students to want to converse in English.	4.52	Highest	3
3. The students have a good understanding of the content and the various simulations created by the teacher.	4.00	Highly	10
4. Enhancing English conversation skills using simulated situations enable students to speak English fluently.	3.49	Moderate	14
5. Incorporating simulation activities into English language teaching helps students to converse in English according to their needs.	3.84	Highly	13
6. Learning English using simulated situations helps students gain more confidence in speaking English.	4.18	Highly	6
7. The English sentences used in the simulation are simple, uncomplicated language that is easy to remember and apply.	3.98	Highly	10
8. The content used in the simulation is similar to everyday English conversation.	4.03	Highly	8
9. Using simulations to enhance English conversation skills allows students to have better interactions with their classmates.	4.77	Highest	2
10. Students have the opportunity to apply the English conversations they have practiced in various simulated situations to real-life situations.	4.02	Highly	9
11. The simulation activities made me more enthusiastic about conversing in English.	3.09	Moderate	11
12. Simulation activities helped me reduce my anxiety about grammatical correctness.	3.44	Moderate	15
13 Simulation activities helped me choose appropriate vocabulary for English conversation.	4.33	Highly	4
14. Simulation activities enabled me to make decisions and solve immediate problems.	4.22	Highly	5
15. Simulation activities made me enjoy learning English conversation; it was fun and not boring.	4.95	Highest	1
	4.12	Highly	

Table 3 shows that, overall, learners were highly satisfied with their English learning experience after being taught English conversation using simulated situations (X = 4.12). Three items received the highest level of satisfaction from learners: Item 2: The content used in the simulations is coherent, interesting, and motivates students to want to converse in English (X = 4.52). Item 9: Using simulations to enhance English conversation skills allows students to have better interactions with their classmates (X = 4.77). Item 15: Simulation activities made me enjoy learning English conversation; it was fun and not boring. (X = 4.95). Two items received moderate satisfaction: Item 4: Enhancing English conversation skills using simulated situations enable students to speak English fluently (X = 3.49). Item12: Simulation activities helped me reduce my anxiety about grammatical correctness. (X = 3.44)

Summary of the Study

Based on a study of Enhancing Business English Conversation Ability by Using Simulation Scenarios for Bachelor Degree Students at North Bangkok University. The results can be summarized as follows:

1. The English conversational ability of the learners increased significantly after the experiment at the .05 statistical significance level. The average score after the experiment was higher than before the experiment, with a mean score of 16.13 before the experiment and 21.37 after the experiment. A comparison between pre- and post-experiment scores showed an increase of 5.24. A t-test revealed a statistically significant difference (p = .05) in the English conversational ability of the students before and after the experiment. This indicates that using simulated situations in English language instruction can effectively improve learners' English conversational skills.

2. The average satisfaction score from students regarding the simulated English conversation scenarios was highly (X = 4.12). Three items received the highest level of satisfaction from students Item 2: The content used in the simulations is coherent, interesting, and motivates students to want to converse in English (X = 4.52). Item 9: Using simulations to enhance English conversation skills allows students to have better interactions with their classmates (X = 4.77). Item 15: Simulation activities made me enjoy learning English conversation; it was fun and not boring. (X = 4.95). Two items

received moderate satisfaction: Item 4: Enhancing English conversation skills using simulated situations enable students to speak English fluently (X = 3.49). Item12: Simulation activities helped me reduce my anxiety about grammatical correctness. (X = 3.44)

Discussions

30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University students who have been strengthened in their ability to converse in English by using simulation situations had higher English conversation ability after the experiment than the statistical significance of the experiment was at the .05 level and there was satisfaction with the use of simulation situations at a good level after the experiment. The results of the experiment can be discussed as follows.

1. Designing learning activities that focus on learners and creating educational experiences language directly to learners using simulation situations to enhance conversational ability English of 30 Bachelor Degree of Business Administration Program in Logistics Management and Supply Chain students (Third Years) in the second semester of the 2025 academic year at North Bangkok University, Researcher in the capacity of an English teacher 5 learning plans have been developed. The plan has been written as a unit plan. Learn according to created simulation situations. When the learning management plan is implemented, skills can be developed. Learners' English conversation can be improved. Because learners have the opportunity to use the language. Practice with friends in groups, they work together and create conversations according to the situations the teacher determines by bringing their knowledge. Compose and create English sentences by themselves. Makes students develop their abilities to converse in English better. This is consistent with Azimova (2019) who stated that today, communities are increasingly facing rapid and profound changes and tensions that affect the social, economic, and political aspects of life. The role of education has also become questionable in the millennial era. A matter of fact, 21st century education requires a gradual shift in curriculum construction focusing on the transferable competencies that learners need to develop in instructional settings. In today's knowledge–based, types of skills and competencies that students need to gain are different from in the past.

Emphasizing the communicative competence is one of the most influential developments in language education. The implementation of communicative activities in EFL/ESL classroom prepares learners to use English in the world beyond based on their own needs, interests and opportunities. This statement is still consistent with Zulfigar et al. (2019) studied about student's need-based learning: The simulation approach in English Teaching found that exploring the students' need for learning and examining the students' speaking improvement in English teaching through the simulation approach. It was a mixed method research applied the combination of a qualitative and quantitative design. 30 participants of the second semester students of English Education department at the Universitas Iqra Buru were involved as the participants of the study. The results found that the students' need was to experience the real-life learning based on their daily activities through the simulation approach that can improve their speaking skill. Xie (2023) studied about using simulation in international business correspondence courses for China's English-major undergraduates stated that this study reports an investigative study with 55 English-major participants in a Chinese university about using simulation in business English correspondence teaching. The study found that participants had strong needs in practical skills development and learning business English correspondence writing. The simulation approach was perceived to be effective and had positive learning outcomes in business communication skills development, motivation, confidence and vocabulary growth, business and language knowledge improvement, and more understanding about the business practice. The constraint factors in simulation included lack of business knowledge and vocabulary, ineffective group cooperation, and lack of understanding about the real-world business background. Wu (2024) studied the scenario simulation teaching design in English oral classroom stated that scenario simulation teaching can bring students a sense of immersion, which is of great significance for improving students' learning experience and cultivating their knowledge application ability. Therefore, scenario simulation teaching has attracted the attention of teachers in teaching. The application of scenario simulation teaching is becoming increasingly widespread, effectively promoting the innovation and reform of English oral teaching. As in the English oral classroom, scenario simulation teaching can exercise students' English language organization and expression abilities, allowing students to flexibly use English in

their future work and life. By building an English classroom based on core literacy, it can ensure students' future learning and development. However, in order to effectively apply scenario simulation in English oral classes, continuous innovation is needed to explore scientific and effective scenario simulation teaching methods, so as to create favorable conditions for the construction of in-depth teaching in English oral classes. The following article will study the strategies for effectively implementing scenario simulation teaching in English oral classes.

2. Students who are taught English conversation skills using simulation situations have satisfaction with learning after the experiment was at a high level. Due to the use of simulation situations,

This allows students to practice using the language and have the opportunity to work together with friends in the group have good interactions with friends in class, students can create English sentences that can be used in conversations by themselves according to the situation. Various simulations are given. When students have problems or errors in the conversation, they participate in solving the problems. Together, students are confident in expressing themselves. Reduce shyness and make English conversation easier and more efficient which is consistent with Oboko and Egemba (2024) studied about Exploring the socio-cultural, intercultural, and technological dimensions of English language teaching in Nigeria: A socio-linguistic study stated that this paper examines the socio-cultural, intercultural, and technological dimensions of English Language Teaching (ELT) in Nigeria, focusing on how Nigeria's linguistic diversity and global communication needs shape the language learning experience. Despite English being the lingua franca, Nigeria's multicultural landscape presents unique challenges, such as phonological interference, lexical transfer, and varied socio-linguistic practices that affect English proficiency. Using data (drawn from experiences) from Nigerian students studying both within Nigeria and in the United Kingdom, this socio-linguistic study highlights the complexities of teaching English within this context and advocates for integrating intercultural studies into the curriculum to enhance cultural competence and global adaptability. Additionally, the study explores how digital tools can modernize ELT in Nigeria, offering more engaging, personalized learning experiences. The research concludes that a holistic approach—embracing cultural awareness, intercultural

communication, and technology—will improve English education in Nigeria and equip students to navigate an interconnected world.

3. When using the English conversation ability scores after the experiment by Criteria-based analysis which the researcher has divided into 4 levels as follows: Group 1, criteria 80% - 100% it can be considered that their ability to converse in English is very good. All students are in this group. There are 11 people and is the largest group of the experiment. Group 2, criteria 70% - 79%, is a group of students. who have good English conversation ability, there are 9 students in this group, Group 3. Criteria 60% - 69% is a group where students have English conversation ability at the passing level Criteria: There are 9 students at this level, which is the same as the number of students at the Good level and Group 4. This is a group of students whose English conversation ability is less than 60%. Students are considered not to pass the criteria. There is 1 student in this group because the said student has learning problems. Learns slowly and takes longer than other students. The researcher solved the problem by giving students practice. Conversate more than other students and allow students to view conversations during conversation exams.

In conclusion, simulation scenario activities can enhance conversation ability. English and students are satisfied with learning activities because students have the opportunity to practice students' use of English for self-conversation. Students have direct experience with the language. Students can use English vocabulary to create sentences to communicate in various situations. In addition, students also have fun learning English. Not bored with studying. Try and be more confident in conversing in English. Another benefit that can be seen clearly, students have good interactions with their classmates. with fellow students doing activities together. The students' skills in working together with others and helping each other resulted in the success of this research. The results were achieved according to the objectives that were set.

Recommendations

1. Using simulation situations to develop or strengthen the ability to Learner's English conversation can be applied to a variety of grade levels, but teachers should

plan, explore, and adjust the content of the simulations created to be appropriate for students age and learner's level.

2. After the students have had the opportunity to practice English conversation from simulated scenarios various things within the classroom teachers should organize activities to expand students' language use by giving them opportunities. Learners practice using English in real situations. By the way, foreign teachers may be invited to talk with students or take students out to learn outside the community or local tourist attractions where there are real foreigners.

3. Teachers should create a variety of other simulation situations for learners or to students be the one who determines the simulation situation that you want to learn by yourself.

4. Simulation activities should be used to develop English conversation ability at other levels, such as junior high school level Vocational education level, etc.

5. Simulation situations should be integrated with learning in other subjects.

Limitations of the Research

1. Methodological Limitations

1.1 Lack of a Control Group: As this research used a quasi-experimental, one-group pre-test – post-test design, there was no control group to compare the results against. This makes it difficult to definitively conclude that the improvement in Business English conversation ability was solely due to the simulation scenarios and not other external factors

1.2 Self-Reported Data: The assessment of student satisfaction relied on a self-assessment form. This can lead to response bias, where students may provide higher ratings due to social desirability or a positive relationship with the instructor rather than an objective evaluation of the learning method.

2. Scope and Generalizability

2.1 Small Sample Size: The study was conducted with a small sample of 30 students. While this is appropriate for a classroom-level experiment, the results may not be generalizable to the entire population of bachelor's degree students at North Bangkok University or other institutions.

2.2 Specific Academic Discipline: The participants were limited to Logistics Management and Supply Chain students. The simulation scenarios used were likely tailored to this field, meaning the findings may not apply to students in other disciplines (e.g., Nursing, Law, or Arts) who require different Business English competencies.

2.3 Single Geographic Location: Being restricted to North Bangkok University, the findings reflect a specific institutional culture and student demographic, which may differ from students in other regions or types of universities.

3. Time and Resource Constraints

3.1 Duration of the Study: The experiment lasted 10 weeks (30 hours total). This relatively short timeframe may measure immediate skill gains but does not account for the long-term retention of conversational proficiency.

3.2 Simulated vs. Real-World Application: While simulations mimic real-life scenarios, they remain controlled environments. The research did not measure how effectively students could transfer these skills into actual business settings or high-pressure professional interactions

4. External Variables

4.1 Prior Proficiency Levels: Although a pre-test was conducted, the study may not have fully accounted for the varying baseline English proficiency or previous international experiences of individual students, which could influence the rate of improvement regardless of the teaching method used.

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Development and Performance Evaluation of a Thesis Circulation System for Graduate Studies at Thonburi University

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Abstract

Study Circulation System for the Graduate School of Thonburi University, designed to replace traditional manual resource management with a secure and efficient digital platform. Utilizing the Agile Methodology for iterative development, the system was built as a web application using PHP and MySQL, with quality assessment conducted based on the ISO/IEC 25010 international standard.

The findings indicate exceptional technical performance, featuring an average search response time of 0.056 seconds and full-text (PDF) access time of 0.075 seconds, both of which significantly surpass international information system standards. Expert evaluation rated the system's Functional Suitability and Reliability at a "Very High" level ($\mu = 4.73$, $\sigma = 0.159$). Additionally, pilot testing with graduate students and administrative staff revealed a "High" level of user satisfaction, specifically regarding Operability ($\mu = 4.44$, $\sigma = 0.527$).

The developed system successfully achieves a complete digital transformation of library management, enhances workflow efficiency through barcode integration, and protects intellectual property via a Secure Full-text Viewing feature, offering a replicable and high-performance model for graduate-level academic resource management.

Keywords: Agile Methodology, Thesis Circulation System, ISO/IEC 25010, Digital Transformation

Background and Statement of the problem

Theses and independent studies constitute vital intellectual property and academic assets for the Graduate School at Thonburi University, representing specialized knowledge derived from systematic research processes. Circulation statistics reveal a consistent upward trend in resource utilization: recorded loans rose from 54 in 2021 to 59 in 2022, 74 in 2023, and reached 82 in 2024. This increasing demand underscores the significance of research works to both students and staff (Graduate School Thonburi University, 2025), yet it simultaneously presents challenges in effective resource management and maintenance. Modern educational institutions are increasingly adopting digital and smart library systems to enhance information accessibility. The integration of information technology and the internet allows libraries to provide more efficient services, better addressing the evolving needs of researchers in the digital era (Le & Bui, 2020).

Currently, the Graduate School's manual operational system faces several critical limitations. Locating specific physical copies is difficult due to poor searchability, while paper-based data management causes delays, increases the risk of document loss, and creates redundant workflows. Furthermore, the lack of real-time monitoring for overdue status hinders the tracking and timely return of resources. These physical-only storage constraints fail to satisfy the growing demand for convenient, online full-text access required by graduate students.

To address these challenges, this research aims to develop and conduct a Development and Performance Evaluation of a Thesis Circulation System for Graduate Studies at Thonburi University to facilitate a complete digital transformation. The proposed system will feature advanced search capabilities categorized by curriculum or popularity, comprehensive statistical dashboards, and secure web-based document viewing to protect intellectual property. Additionally, the system will streamline administrative tasks through barcode integration for loans and returns, facilitate physical book reservations, and establish a systematic membership database. These enhancements are designed to elevate the university's information service standards, ensuring optimal efficiency and academic benefit for the graduate community.

Objective

1. To develop a Graduate Thesis and Independent Study Circulation System for Thonburi University with comprehensive functionalities, including searching, physical book reservation, circulation (borrowing and returning), and full-text access under a secure data protection system.

2. To test the technical efficiency of the developed system regarding search accuracy and system response time, in accordance with software testing standards.

3. To evaluate user satisfaction (among students and staff) towards the Thesis and Independent Study Circulation System in terms of usability and the practical benefits of its data management functions.

Expected benefits

1. The acquisition of an efficient Graduate Thesis and Independent Study Circulation System for Thonburi University, which streamlines workflows by reducing paper-based processes and minimizing data management errors through barcode technology.

2. Graduate students will be able to conveniently search for and access full-text thesis documents via the network, supported by a security system that prevents copyright infringement from copying or printing.

3. A comprehensive understanding of the system's technical efficiency and user satisfaction levels, serving as a guideline for further improving information systems and library services at the Graduate School, Thonburi University, in the future.

Conceptual Framework

This research framework illustrates the development and efficiency evaluation process of the Graduate Thesis and Independent Study Circulation System at Thonburi University. The development integrates Agile Methodology to ensure maximum flexibility and responsiveness to user requirements, alongside modern Information System Design principles. Evaluation criteria are established in accordance with the ISO/IEC 25010 international software quality standard. This framework is divided into two systematically interconnected components as follows.

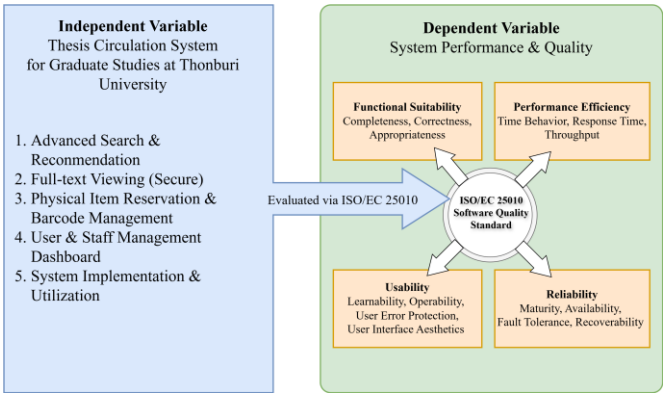


Figure 1 Conceptual Framework

This framework demonstrates the structural relationship between the developed system (independent variable) and the performance and quality outcomes (dependent variable), with details as follows

1. Independent Variable

The developed Graduate Thesis and Independent Study Circulation System for Thonburi University, which encompasses five core functional areas.

- Advanced Search & Recommendation, An advanced search engine and recommendation system for related items.

- Secure Full-text Viewing, Online access to full-text documents protected by a secure data system.

- Physical Item Reservation & Barcode Management, A reservation system for physical thesis copies managed through barcode technology.

- User & Staff Management Dashboard, A central management dashboard for both students and administrative staff.

- System Implementation & Utilization, The deployment and real-world application of the system within the university environment.

2. Dependent Variables

System Performance and Quality, representing the outcomes derived from the system development, evaluated based on the ISO/IEC 25010 standard across four primary dimensions.

- Functional Suitability, Assessing functional completeness, correctness, and appropriateness.

- Performance Efficiency, Measuring time behavior, response time, and throughput.

- Usability, Evaluating learnability, operability, user error protection, and user interface aesthetics.

- Reliability, Measuring availability, fault tolerance, and recoverability.

Research Methodology

The study employs the Agile Methodology to ensure system flexibility and responsiveness. The process is divided into four key phases. (Abrahamsson et al., 2002)

1. Requirement Analysis

- Preliminary Study, Analyzed 4-year circulation statistics (2021-2024) and existing regulations of the Graduate School Library, Thonburi University.

- Elicitation, Conducted interviews with staff and students to define User Stories, focusing on advanced search, secure full-text access, and automated circulation management.

2. System Design & Development

The research team executed the development process under the Agile framework, organizing workflows into iterative cycles or "Sprints" to facilitate immediate feedback and continuous refinement. The details are as follows.

- Architecture & Database, Designed an ERD using a Relational Database model (InnoDB, UTF-8). It encompasses User data, Research metadata, Transaction logs (Borrow/Return/ Fines), and Security logs.

- UI/UX Design, Developed Information Architecture (IA), Wireframes, and Prototypes. The design follows the university's visual identity (Purple & White) and ensures Respon-sive Design across all devices.

- Implementation, Developed using PHP, HTML, CSS, JavaScript, and SQL. Integrated a Barcode system for operational efficiency and Anti-Copy measures (e.g., suspicious activity detection) to protect intellectual property.

3. Testing & Evaluation

- Expert Evaluation, conducted with 5 information technology and software development experts selected through Purposive Sampling. They verified Functional

Suitability, Reliability, and UI/UX Aesthetics. A panel of 5 experts is academically recognized as sufficient for software quality evaluation, as this number is capable of identifying the majority of significant usability and functional issues. (Nielsen & Landauer, 1993)

- Technical Testing, Measured Performance Efficiency, focusing on Response Time and Throughput during concurrent usage. (Thonghuapai, 2015)

4. User Satisfaction Assessment

- Population and Sample, the sample consisted of 33 participants, including graduate students and relevant administrative staff from Thonburi University. The participants were selected using Purposive Sampling, focusing on those who actively engaged with the system during the pilot testing phase.

- Sample Size Justification, a sample size of 33 is considered adequate and academically sound for usability and performance evaluation. In information system research, a sample exceeding 30 is typically sufficient to achieve a normal distribution of data, allowing for reliable descriptive statistical analysis (Mean and Standard Deviation) to accurately reflect user satisfaction levels.

- A 5-point Likert Scale questionnaire was used to evaluate Usability (ease of use) and overall system satisfaction. The interpretation of mean scores was based on the criteria proposed by Likert (1932), whereby scores ranging from 4.51 to 5.00 indicate a "Very High" level of satisfaction, scores from 3.51 to 4.50 indicate "High," scores from 2.51 to 3.50 indicate "Moderate," scores from 1.51 to 2.50 indicate "Low," and scores from 1.00 to 1.50 indicate "Very Low."

- Data Analysis, Utilizing descriptive statistics, including Mean (μ) and Standard Deviation (σ), to summarize the system's quality and performance outcomes.

Table 1 Summary Table of Evaluation Criteria

Evaluation Topics	Evaluation methods	Tools	Target Audience
1. Functional Suitability	Completeness, Correctness, Appropriateness	1. Software Quality Evaluation Form 2. Black-Box Testing Checklists	Expert
2. Performance Efficiency	Time Behavior, Response Time, Throughput	3. Automated Testing Tools (Apache JMeter)	Load Test
3. Usability	Learnability, Operability, User Error Protection, UI Aesthetics	4. User Satisfaction Questionnaire 5. System Usability Scale (SUS)	Users
4. Reliability	Maturity, Availability, Fault Tolerance, Recoverability	6. Test Scripts	Expert

Note: Evaluation Topics and Evaluation methods from Kongvasagunnee & Chooprayoon (2024)

Research Results

The research findings for the "Development and Efficiency Evaluation of the Thesis and Independent Study Circulation System for the Graduate School, Thonburi University" are presented below, categorized according to the research objectives.

Part 1 System Development Results.

The results in this section highlight the functional characteristics of the system developed as a web-based application. The system comprises key modules aligned with the operational scope, as illustrated in the following interface screenshots.

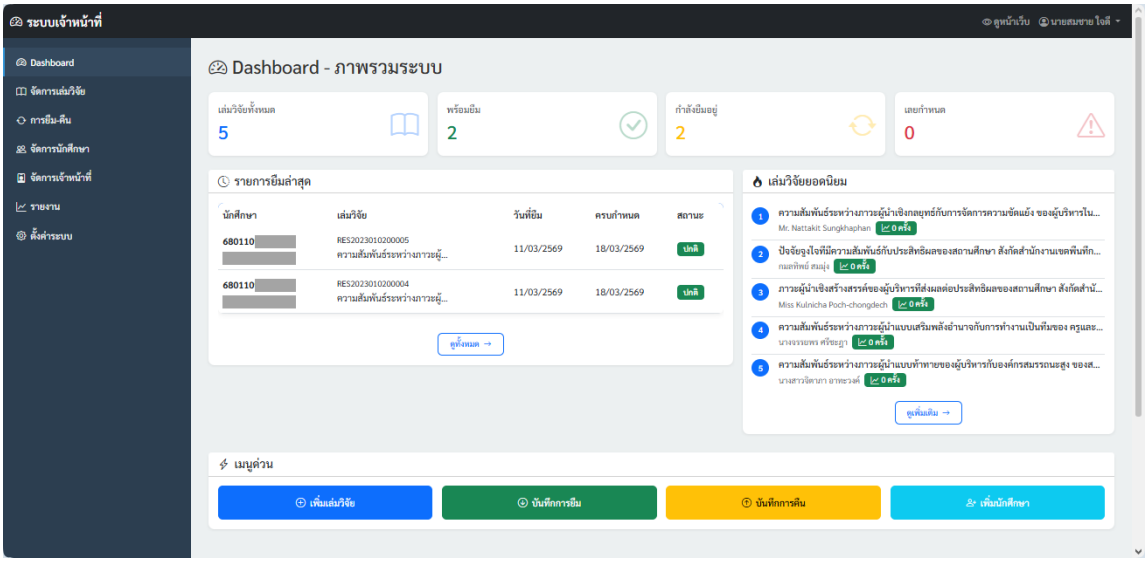


Figure 2 Display the system's main dashboard.

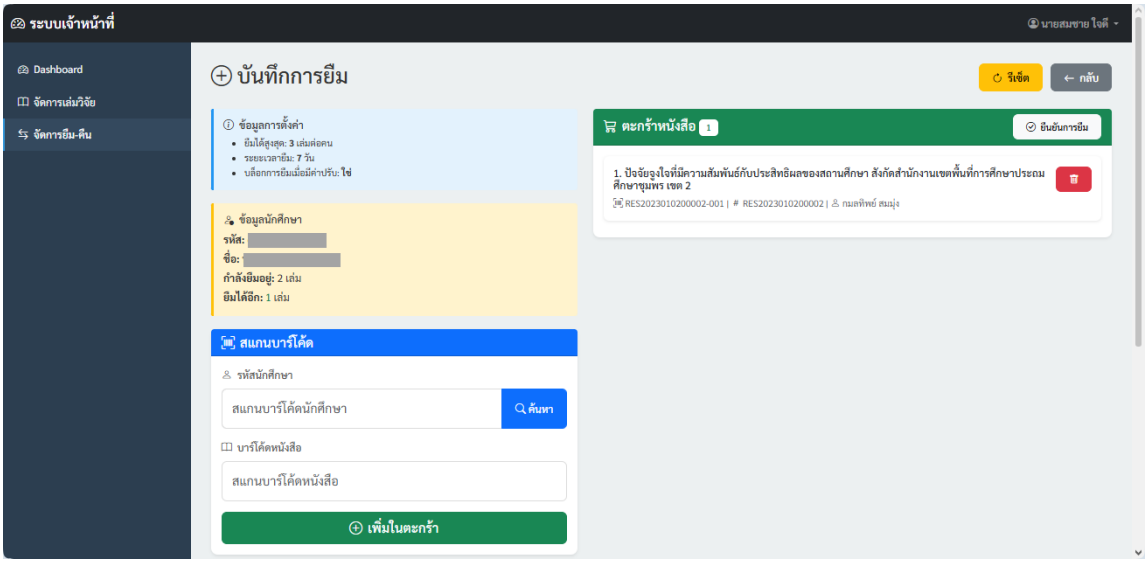


Figure 3 Borrowing Management Screen.

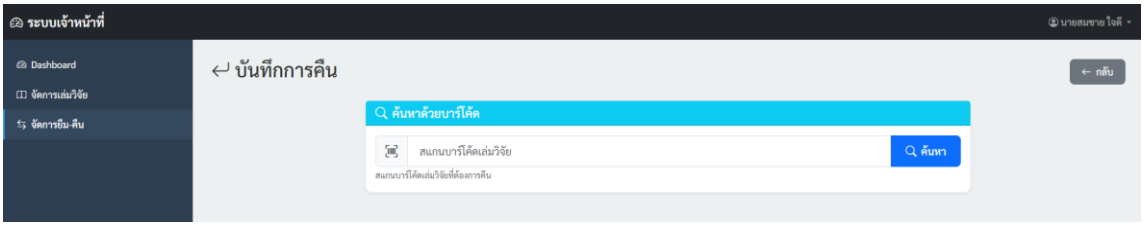


Figure 4 Barcode scanner page for book return.

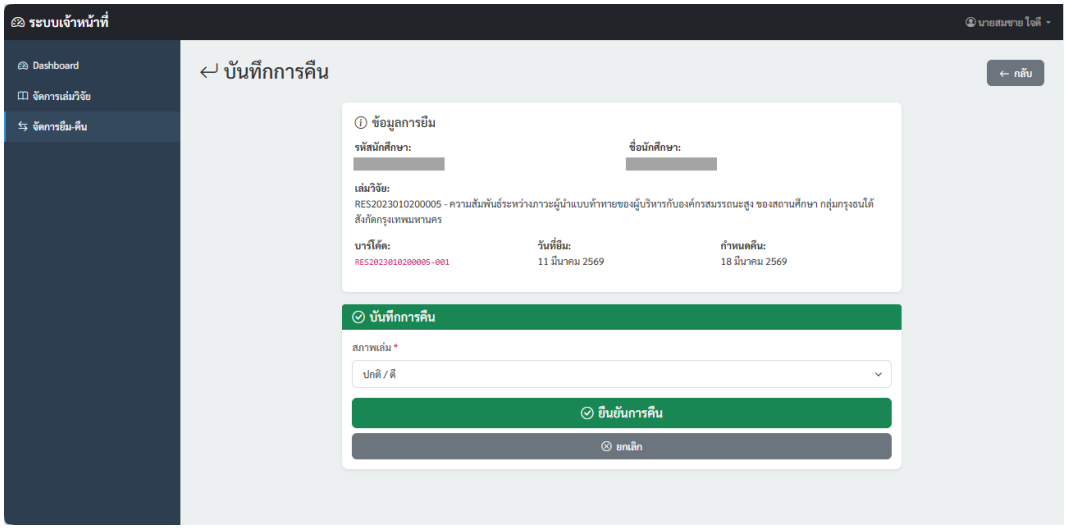


Figure 5 Return management Screen.

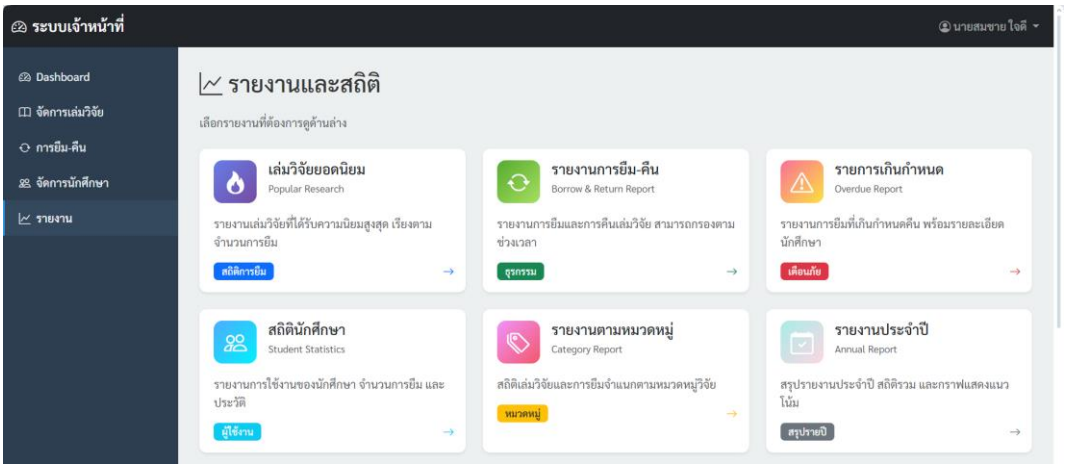


Figure 6 Data report Screen.

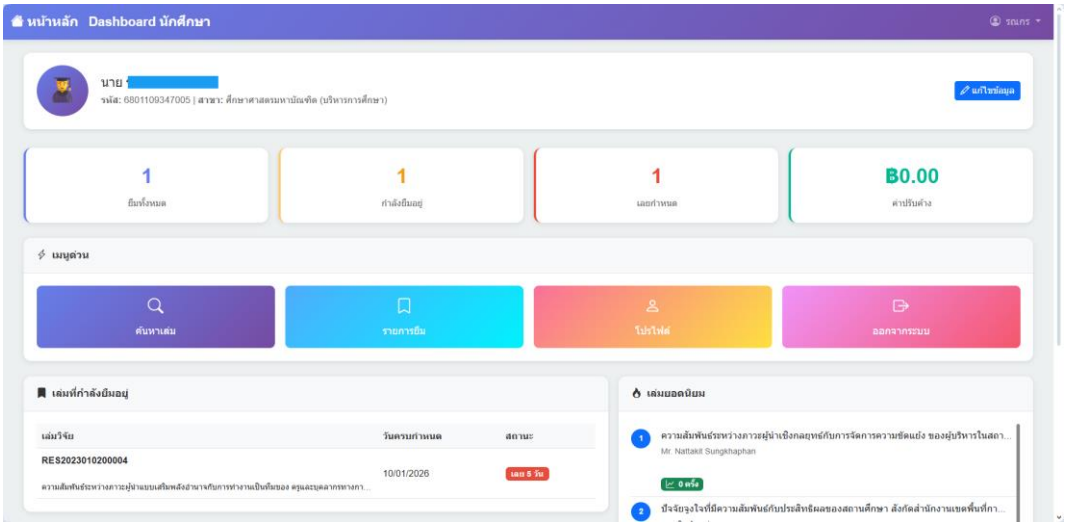


Figure 7 Student system main screen.

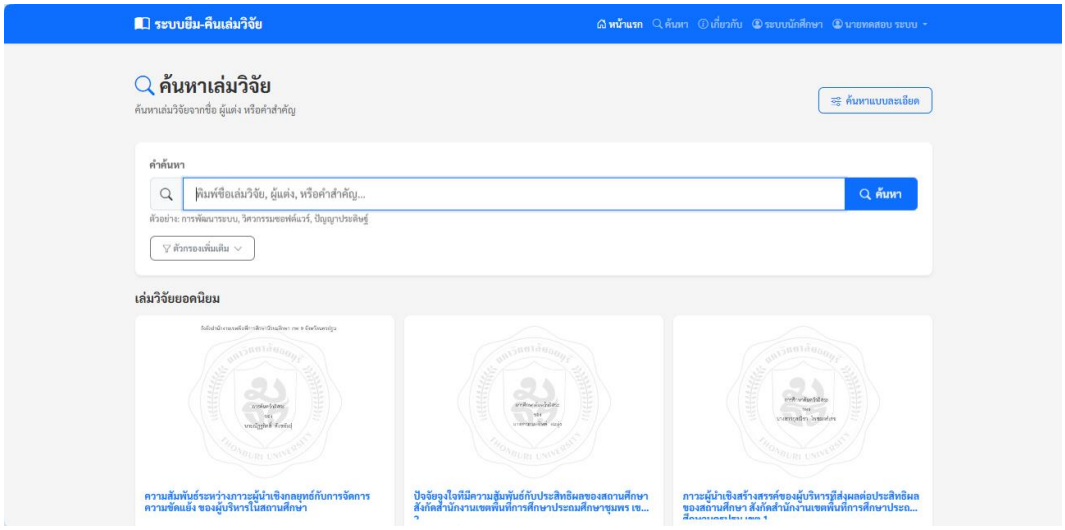


Figure 8 Volume search screen.

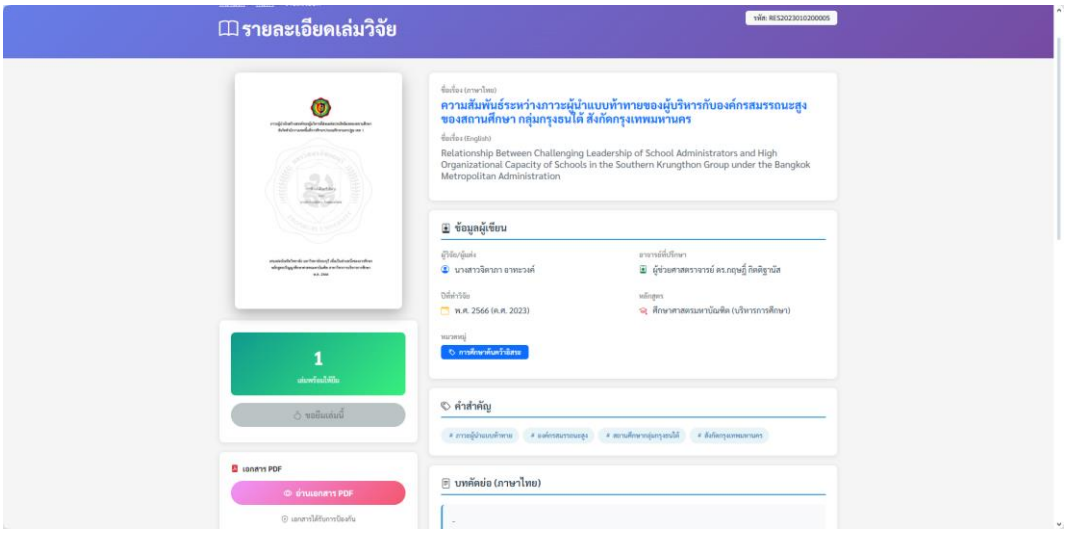


Figure 9 Thesis details page.



Figure 10 Full-text display page

Part 2 Results of Technical Performance Efficiency Testing.

The research team conducted performance testing of the system utilizing the Apache JMeter tool to evaluate time behavior and throughput. The results of these tests are presented in Table 2.

Table 2 Results of the System's Technical Performance Testing.

Performance Testing Topics	Actual Result	Target	Std. Dev.	Pass / Fail
1. Response Time (Search Thesis)	0.056 s	< 2 s	0.0339	Pass
2. Response Time (Load PDF)	0.075 s	< 3 s	0.0131	Pass
3. Throughput	36.8 TPS	> 10 TPS	-	Pass
4. Time Behavior	0.065 s	< 5 s	0.0274	Pass

According to Table 2, the system recorded an average thesis search time of 0.056 seconds and an average full-text (PDF) access time of 0.075 seconds. These values are significantly below the established thresholds of < 2 seconds and < 3 seconds, respectively. This clearly demonstrates the system's ability to respond to user requests rapidly without perceived latency, making it highly suitable for an educational information system. Regarding the throughput test, the system achieved an average processing rate of 36.8 Transactions Per Second (TPS), which exceeds the minimum requirement of > 10 TPS. This indicates that the system possesses high potential for handling concurrent user sessions and can effectively accommodate future user growth. Furthermore, the Time Behavior analysis, which measures the system's capacity to maintain response times under high-load conditions, was tested with 20 simulated concurrent users. The results showed a Total Average Response Time of 0.065 seconds, well below the established limit of < 5 seconds. Following performance guidelines for web-based information systems, average response times should remain under 5 seconds to ensure a seamless user experience (Rempel, 2015). In conclusion, the system exhibits high stability and the capability to support concurrent usage without significant delay issues.

Part 3 Results of Quality Evaluation by Experts according to the ISO/IEC 25010 Standard.

The research team presented the developed system to five experts in information technology to evaluate its quality in terms of Functional Suitability and Reliability. The results of the expert evaluation are presented in Table 3.

Table 3 The results of the system quality assessment by experts.

Evaluation list	Evaluation		
	μ	σ	Results
Functional Suitability	**4.75**	**0.167**	**Very High**
1. Functional Completeness (q1.1 - q1.4)	4.65	0.418	very high
2. Functional Correctness (q1.5 - q1.8)	4.70	0.274	very high
3. Functional Appropriateness (q1.9 - q1.12)	4.90	0.224	very high
Reliability	**4.71**	**0.185**	**Very High**
4. Stability, Integrity and Reliability (q2.1 – q2.4)	4.85	0.223	very high
5. Availability (q2.5 – q2.8)	4.65	0.335	very high
6. Fault Tolerance (q2.9 – q2.12)	4.55	0.447	very high
7. Recoverability (q2.13 – q2.16)	4.80	0.209	very high
Total average	**4.73**	**0.159**	**Very High**

The quality evaluation results from the five experts regarding Functional Suitability and Reliability, based on the ISO/IEC 25010 standard, revealed that the overall system quality is at a "Very High" level (μ = 4.73, σ = 0.159). The top three items with the highest mean scores (out of 5.00) were: functional completeness of core features (q1.1), data processing accuracy (q1.8), and data accuracy following system recovery (q2.15). Conversely, the items with the lowest mean scores, averaging 4.40, were proper system resource management (q2.8) and protection against data loss due to user error (q2.12). The experts provided recommendations regarding server-side memory management efficiency and the development of a more granular proactive data entry validation system. In conclusion, these findings indicate that system development via the Agile methodology, combined with ISO/IEC 25010 quality assessment, ensures high levels of Functional Suitability and Reliability, effectively and securely supporting Thonburi University's intellectual property management processes.

Part 4 Results of User Satisfaction and Usability Assessment.

The research team implemented the developed system for pilot testing with a sample group consisting of 33 graduate students from Thonburi University and relevant administrative staff to evaluate usability satisfaction according to the ISO/IEC 25010 standard. The findings are summarized in Table 4.

Table 4 Results of the usability and user satisfaction assessments.

Evaluation list	Evaluation		
	μ	σ	Results
1. Learnability	4.28	0.495	high
2. Operability	4.44	0.527	high
3. User Error Protection	4.33	0.498	high
4. User Interface Aesthetics	4.35	0.562	high
5. Overall benefits and satisfaction.	4.22	0.572	high
Total average	4.35	0.446	high

Based on the analysis of the satisfaction assessment for the Graduate Thesis and Independent Study Circulation System at Thonburi University, it was found that users expressed a "High" level of satisfaction across all dimensions. The most prominent mean score was observed in Operability or ease of use (μ = 4.44, σ = 0.527), reflecting the success in designing simplified workflows that facilitate rapid access to full-text information. This was followed by user interface aesthetics (4.35) and user error protection (4.33), both of which contributed to a more refined user experience. However, while the dimension of perceived usefulness and overall satisfaction also fell within the "High" range, it received the lowest score among all categories (4.22). This suggests an area for developers to further consider in order to distinguish the system's value proposition more clearly, ensuring it matches the high level of convenience achieved in other dimensions.

Summary of the Study

The research project titled "Development and Efficiency Testing of the Online Thesis and Independent Study Circulation System at Thonburi University" successfully developed a system that addresses real-world operational needs through the Agile Methodology. This approach emphasized iterative development and flexibility centered

on user requirements (Panyadee & Mateesuwapap,2023). Technical performance testing revealed exceptionally high system speed, with an average search time of only 0.056 seconds and a full-text document access time of 0.075 seconds, both surpassing information system response standards. Furthermore, the expert quality evaluation based on the ISO/IEC 25010 standard resulted in a "Very High" level (average 4.73), with the highest performance observed in Functional Suitability. Concurrently, actual users expressed a "Quite High" level of satisfaction (average 4.35), particularly in Operability, which effectively reduced redundant workflows and accelerated access to information resources.

The practical application of this research focuses on the complete digital transformation of library management. Integrating barcode technology with physical copy management has minimized documentation errors and reduced operational time for administrative staff, aligning with the findings of Daorueng et al. (2025), which demonstrated the success of barcode implementation in library tasks. Additionally, the system ensures data security through the Secure Full-text Viewing function, which prevents unauthorized copying and printing, effectively protecting the intellectual property rights of graduate research. The utilization of an agile framework also enables the institution to refine system features in accordance with evolving market trends and student demands (Alsaqqa et al., 2020), ensuring that the university's research resource management meets international standards and provides maximum benefit to students and researchers.

Regarding future research directions and inquiries, experts have recommended enhancing server-side memory management and developing a more granular proactive data entry validation system. Future studies should explore the integration of advanced technologies aligned with the Smart Library concept. This includes implementing Biometric systems to elevate security and prevent identity theft, as suggested in the research by Choorod et al. (2013), or applying the Internet of Things (IoT) in conjunction with AI Chatbots to enable real-time resource tracking and automated user responses. (Hong & Hieu, 2021) Such advancements would expand the system's capabilities into a more intelligent framework, encompassing diverse and complex needs in the digital era.

Discussions

The findings of this research demonstrate that the Thesis Circulation System for Graduate Studies at Thonburi University, developed in this study, achieves a high level of technical efficiency and system quality. This outcome can be attributed to the application of Agile Methodology in the system development process, which emphasizes iterative development cycles and active stakeholder participation. Through this approach, developers are able to continuously refine system functions based on user feedback throughout the development stages. This finding is consistent with the study by Alsaqqa et al. (2020), which reported that Agile methodologies enable development teams to rapidly adapt to changing requirements while minimizing communication gaps between developers and system users. Consequently, the developed system can more effectively address the practical needs of graduate students and academic staff within the university.

Regarding system performance efficiency, the evaluation results indicate that the developed system achieved response times for search and document retrieval between 0.056 and 0.075 seconds, which can be considered exceptionally fast. These results significantly exceed common usability expectations for academic information systems. According to the performance evaluation guidelines proposed by Rempel (2015), response times for information retrieval systems should not exceed 5 seconds in order to avoid user perception of latency and maintain satisfactory user experience. Therefore, the response time observed in this research is substantially lower than the recommended threshold, indicating that the system is capable of providing highly responsive services to its users.

When comparing these results with previous studies in the field of digital library systems and academic information systems, the performance outcomes of this research demonstrate comparable or superior efficiency. For instance, Breeding (2011) highlighted that rapid system responsiveness and efficient information retrieval are key determinants of user satisfaction and successful system adoption in academic libraries. Likewise, Candela et al. (2007) emphasized that digital library infrastructures play a critical role in enabling efficient access to scholarly resources and supporting research and knowledge discovery. In this regard, the extremely low response times achieved by the developed

system reflect strong technical capability and align well with international standards for digital library systems.

In addition to the system's performance capabilities, the integration of barcode technology for managing physical thesis collections has further improved operational efficiency within the circulation process. This result corresponds with the findings of Daorueng et al. (2025), who reported that barcode-based circulation systems significantly reduce transaction time and human errors compared with traditional manual record-keeping methods. By automating the loan and return procedures, the developed system enhances workflow efficiency and reduces administrative workload for library staff.

From an operational perspective, the integration of Agile-based development practices, high-performance system architecture, and barcode-supported circulation management contributes to the overall reliability and scalability of the system. These characteristics are particularly important for academic information systems that must accommodate increasing numbers of users and expanding collections of scholarly resources. Therefore, the Thesis Circulation System for Graduate Studies at Thonburi University, developed and evaluated in this study, demonstrates strong potential to sustainably support the future development of digital information services within the university.

Recommendations

Based on the findings of this research, the researcher provides the following recommendations for practical application and future research.

1. Integration of IoT Technology: Future research should integrate Internet of Things (IoT) technology with online notification systems to enhance the efficiency of real-time monitoring and tracking of resource statuses and locations. This aligns with the approach of Pamungkas et al. (2025), who found that IoT systems facilitate resource management that is more transparent and rapid than traditional systems.

2. Enhancing Security with Biometrics: Further study and implementation of Biometric technologies, such as fingerprint scanning for identity verification during circulation transactions, should be explored. Replacing traditional passwords or member cards with biometric authentication would elevate security levels and prevent unauthorized access

or identity theft. As presented by Choorod et al. (2013), such advancements significantly increase satisfaction and bolster security for library users.

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Legal Measure in Increasing Birth Rate Promotion

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Abstract

The objective of the research is to suggest and develop the law to solve problems related to legal measure in increasing birth rate promotion. This research is based on a qualitative research and analysis from documents as follows: The study included a study of documents, concepts and theories as a basis for research from both primary and secondary sources, for example, concepts, theories and laws related to protect children and youth from cyber bullying, were analyzed and studied from books, textbooks, research reports, theses, using the library and library databases in Thai and foreign languages.

In this study, it was found that 1) law in increasing birth rate promotion has been enforced for a long time, the provision related to these are inappropriate with current circumstances; 2) there is a problem of the lack of a primary agency directly responsible related in increasing birth rate promotion.

The authors suggest that amendments in Labour Protection Act B.E. 2541, National Education Act B.E. 2542 (1999), Child Protection Act, B.E. 2546 (2003), Prime Minister's Office Regulations Concerning Leave of Absence for Government Officials B.E. 2555 (2012) and related laws shall include changes related to children must receive an education while working and children cannot work during school hours, free education up to the bachelor's degree level, and educational institutions should be prohibited from charging any fees including free breakfast and lunch arrangement in school, establishing a childcare center for working parents with minimal or no cost, paid maternity leave for one year and father took leave to raise his child for one year.

Keywords: Legal Measure, Birth Rate, Promotion

Background and Statement of the problem

Thailand Many sectors have begun to realize and see the importance of stepping into an aging society. due to fear that Thailand's Total Fertility Rate (TFR) is rapidly declining. It will not be conducive to the economic and social development of the country. by the country's development guidelines in the past This has resulted in the country's total fertility rate continuing to decline, causing in 2021 Thailand to have more deaths than births for the first time. (Based on official population statistics from the Civil Registration Bureau, Department of Provincial Administration) In 2021 (January to December), Thailand had 19,080 more deaths than births, while in 2020, the number of births exceeded deaths by 85,930. (Sasin Graduate Institute of Business Administration, 2023) Furthermore, estimates of Thailand's fertility rate show a continuous downward trend, projected to reach approximately 1.3 children by 2040.(Office of the National Economic and Social Development Council, 2023) This leads to Thailand facing a declining birth rate, resulting in a demographic shift with an increasing elderly population and a shortage of children, which may not be enough to replace the working-age population in the future. (Workpointtoday.com., 2023) This may be because existing measures and policies are not adequately addressing the needs (Research Café, 2023)

Overall, the decision to have children is based on the costs and expected benefits of having children. The costs of having children can be categorized into five parts: direct economic costs, income-related opportunity costs, non-income-related opportunity costs, psychological costs, and physical costs, according to Becker's (1960) theory of childbearing decision.(Department of Health, 2024) Another important reason for the low birth rate is that parents planning to have children must be prepared to dedicate almost all of their time to childcare and be ready to sacrifice money for various child expenses for at least 20 years. (Department of Health, 2024) Therefore, measures should be in place to sustainably increase birth rates in order to mitigate the impacts of demographic changes, support an aging society, and reduce the future dependency burden of the working-age population. (Isranews, 2024)

Changes in lifestyle, economic conditions, employment, and values have impacted the lives, attitudes, and thinking of people in society, resulting in a declining birth rate in Thailand. Therefore, existing legal and policy measures have failed to encourage Thai

people to have more children. Therefore, it is deemed appropriate to review laws related to promoting births and growth and to study the feasibility of improving existing laws or enacting new laws with the goal of ensuring that citizens have rights and access to social welfare services in order to promote quality births and growth.

Objective

1. To examine and analyze problems related to legal measure in increasing birth rate promotion
2. To examine concepts and laws related to legal measure in increasing birth rate promotion
3. To develop related law to solve problems related to legal measure in increasing birth rate promotion

Expected benefits

1. Receiving examine and analyze problems related to legal measure in increasing birth rate promotion
2. Receiving examine concepts and laws related to legal measure in increasing birth rate promotion
3. Proposed policies for law development to solve problems related to legal measure in increasing birth rate

Research Methodology

This research is based on a qualitative research and analysis from documents as follows: The study included a study of documents, concepts and theories as a basis for research from both primary and secondary sources, for example, concepts, theories and laws related to legal measure in increasing birth rate promotion, were analyzed and studied from books, textbooks, research reports, theses, using the library and library databases in Thai and foreign languages.

Research Results

1. The authors found that legal measure in increasing birth rate promotion is basic right for people and people have right to access basic service equally with no expenses. The decision to have children is complex, but the main reasons for deciding to have children are economic factors and the opportunity to raise them. Especially nowadays, the focus is on quality over quantity in childcare. Building a good future for children requires a lot of money, particularly in education and healthcare, (Institute for Population and Social Research and The Thailand Research Fund, 2026) However, law in increasing birth rate promotion has been enforced for a long time, the provision related to these are inappropriate with current circumstances, which does not affect the decision to have children and quality of child care, for examples as follows:

1) Civil Servant Welfare

Prime Minister's Office Regulations Concerning Leave of Absence for Government Officials B.E. 2555 (2012) Article 19. Providing that Civil servants who wish to take maternity leave must submit or send their leave application to their supervisor in hierarchical order until it reaches the person authorized to grant permission, before or on the day of leave, unless they are unable to sign the leave application. In such cases, another person may sign on their behalf. However, once they are able to sign, the leave application must be submitted or sent promptly, without the need for a medical certificate.

Maternity leave can be taken on the day of delivery, before, or after the day of delivery, but the total number of days of leave combined must not exceed 90 days. (Ministry of Social Development and Social security, 2012)

Royal Decree Medical Welfare Benefits B.E. 2553 (2010) Section 4 of this Royal Decree Providing that

"Eligible persons" means:

(1) Civil servants and permanent employees who receive salaries or permanent wages from the budget expenditure, personnel budget of ministries, departments, and agencies, except for police officers of the rank of police constable who are in the process of receiving education or training in an educational institution of the Royal Thai Police before commencing their official duties.

(3) Persons receiving regular pensions or special pensions due to disability under the law on civil servant pensions or the law on the civil servant and reserve military pension fund, receive an allowance according to the Ministry of Defence regulations on allowances.

"Family member" means:

(1) Legitimate children of the person entitled to the right, who are minors or have reached maturity but are incapacitated or deemed incapacitated and are under the care and support of the person entitled to the right.

However, this does not include adopted children or children who have been given up for adoption to another person.

(2) The legal spouse of the person entitled to the right.

(3) The legal father or mother of the person entitled to the right.

Royal Decree Medical Welfare Benefits B.E. 2553 (2010) Section 6 states that eligible persons are entitled to receive medical welfare benefits for their children only for the first to the third child.

If a person entitled to benefits has more than three children, and subsequently one of those three children dies before reaching adulthood, that person shall be entitled to receive medical welfare benefits for the child, an amount equal to the number of the deceased child, starting with the next child in line.

Children are counted in chronological order of birth, regardless of the marriage or whether they are under one's custody.

Royal Decree Medical Welfare Benefits B.E. 2553 (2010) Section 8 states that Eligible individuals are entitled to receive medical welfare benefits for themselves or their family members in the following cases:

(1) Receiving medical treatment at a government medical facility, either as an outpatient or an inpatient.

(2) Receiving medical treatment at a private medical facility according to the criteria set by the Ministry of Finance, type of inpatient.

(3) Receiving medical treatment at a private medical facility other than the medical facility under (2),

Type of inpatient, only in cases where the eligible person or a family member has an accident, disaster, or has an urgent need, which, if not receiving immediate medical treatment, may be life-threatening.

(4) Receiving medical treatment at a private medical facility as determined by the Ministry of Finance, as an outpatient, on an occasional basis, because a government medical facility needs to refer the patient to that private medical facility, whether or not it is a private medical facility under this Royal Decree.

Payment of medical welfare benefits shall be made for medical expenses in accordance with the criteria, types, and rates determined by the Ministry of Finance. (The Comptroller General Department, 2026)

2) Social Security Service

Social Security Act B.E. 2533 providing that Section 65. An insured person is entitled to maternity benefits for himself or his wife only if, within fifteen months prior to the date of receiving medical services, the insured person has paid contributions for at least five months.

In cases where the insured person has no wife, if he openly lives with any woman as husband and wife according to the regulations set by the Secretary-General, the insured person is entitled to maternity benefits for that woman as well.

Social Security Act B.E. 2533 providing that Section 66 Maternity benefits include:

(1) Prenatal care and examination fees

(2) Medical treatment fees

(3) Medication and medical supply fees

(4) Delivery fees

(5) Living and medical care fees at a medical facility

(6) Newborn care and medical treatment fees

(7) Ambulance or patient transport fees

(8) Other necessary service fees

This is in accordance with the criteria and rates determined by the Medical Committee with the approval of the Board.

Insured persons who have to take time off work for maternity leave are entitled to a maternity leave allowance according to the criteria stipulated in Section 67.

Social Security Act B.E. 2533 providing that Section 67 In cases where an insured person has to stop working for maternity leave, the insured person is entitled to a maternity leave allowance for a maximum of two times, paid as a lump sum at the rate of fifty percent of the wages as stipulated in Section 57, for a period of ninety days. (Ministry of Labour, 1990)

Labour Protection Act B.E. 2541 Section 41 grants female employees who are pregnant the right to maternity leave for a term not exceeding one hundred and twenty days per pregnancy, or the number of days specified in a Royal Decree.

Maternity leave under this section shall include leave for prenatal checkups.

The leave days referred to in paragraph one shall include any holidays that occur during the leave period.

Female employees who have exercised their maternity leave rights under the first paragraph are entitled to continue taking care of their child for a period not exceeding fifteen days, in cases where the child has a medical condition that is at risk of complications, has abnormalities, or has disabilities. The employee must provide a medical certificate from a licensed physician when applying for leave.

Labour Protection Act B.E. 2541 Section 41/1 Employees are entitled to take leave to assist their spouse who gives birth to one pregnancy, for a period not exceeding fifteen days. This entitlement can be exercised on or before the start of the leave, within ninety days of the childbirth.

Labour Protection Act B.E. 2541 Section 42 In cases where a pregnant female employee presents a certificate from a qualified physician stating that she cannot continue performing her original duties, she has the right to request that her employer temporarily change her job before or after childbirth. The employer shall then consider providing her with a suitable replacement job.

Labour Protection Act B.E. 2541 Section 43 Employers are prohibited from terminating the employment of female employees because of pregnancy. (Department of Labour Protection and Welfare, 2000)

3) Tax Deductions for Children/Parents

Revenue Code Section 47 The assessable income under Section 40, after deductions under Sections 42bis to 46, in order to alleviate the tax burden, can be further deducted as follows: (1) Deduction for

C) Children

(1) Legitimate children of the income earner or legitimate children of the income earner's husband or wife, 30,000 baht each.

(2) An adopted child of an income earner is entitled to 30,000 baht per child, but the total number of children must not exceed three.

In the case where the taxpayer has both (1) and (2) children, the deduction for the children shall first deduct all the children under (1) and then deduct the children under (2), except in the case where the taxpayer has three or more living children under (1), in which case the children under (2) cannot be deducted. However, if the number of children under (1) is less than three, the children under (2) can be deducted, provided that when combined with the children under (1), the total does not exceed three.

When counting the number of children, only living children should be counted, in order of their age, including children who do not meet the eligibility criteria for the deduction.

The deduction for children is only applicable to children under the age of twenty-five who are still studying at a university or higher education institution, or who are minors, or who have been declared by the court to be incompetent or quasi-incompetent, and who are under one's care and support. However, no deduction is allowed for such children who had assessable income in the preceding tax year of 30,000 baht or more, provided that such assessable income does not fall under the characteristics of Section 42.

The deduction for such children can be claimed throughout the tax year, regardless of whether the circumstances under which the deduction is applicable

throughout the tax year or not. In the case of adopted children, the deduction can only be claimed in the capacity of an adopted child.

(3) In the case where the income earner is not a resident of Thailand, the deductions under (1), (b), and (c) are only applicable to the spouse and children who are in Thailand. (The Revenue Department, 2026)

2) The author found that there is a problem of the lack of a primary agency directly responsible related in increasing birth rate promotion, which are not yet conducive to quality birth and growth, their specific roles and responsibilities are as follows:

1) Constitution of the Kingdom of Thailand, B.E. 2560 (2017)

Constitution of the Kingdom of Thailand, B.E. 2560 (2017) Section 27.

All persons are equal before the law, and shall have rights and liberties and be protected equally under the law.

Men and women shall enjoy equal rights.

Men and women shall enjoy equal rights. Unjust discrimination against a person on the grounds of differences in origin, race, language, sex, age, disability, physical or health condition, personal status, economic and social standing, religious belief, education, or political view which is not contrary to the provisions of the Constitution or on any other grounds, shall not be permitted.

Measures determined by the State in order to eliminate an obstacle to or to promote a person's ability to exercise their rights or liberties on the same basis as other persons or to protect or facilitate children, women, the elderly, persons with disabilities or underprivileged persons shall not be deemed as unjust discrimination under paragraph three.

Members of the armed forces, police force, government officials, other officials of the State, and officers or employees of State organizations shall enjoy the same rights and liberties as those enjoyed by other persons, except those restricted by law specifically in relation to politics, capacities, disciplines or ethics.

Constitution of the Kingdom of Thailand, B.E. 2560 (2017) Section 54. The State shall ensure that every child receives quality education for twelve years from pre-school to the completion of compulsory education free of charge.

The State shall ensure that young children receive care and development prior to education under paragraph one to develop their physical body, mind, discipline, emotion, society and intelligence in accordance with their age, by also promoting and supporting local administrative organizations and the private sector to participate in such undertaking. The State shall undertake to provide the people education as needed in various systems including promoting life-long learning, and to enable the cooperation among the State, local administrative organizations and private sector in providing every level of education, which the State has the duty to carry out, supervise, promote and support the provision of education to be of quality and to meet international standards as provided by law on national education which shall, at least, contain provisions relating to national education plan, and implementation and inspection to ensure the compliance with the national education plan.

All education shall aim to develop learners to be good, disciplined, proud of the Nation, skillful in their own aptitudes and responsible for family, community, society and the country.

In undertaking to provide young children to receive care and development under paragraph two or to provide people the education under paragraph three, the State shall undertake to provide persons with insufficient means with financial support for educational expenses in accordance with their aptitudes.

A fund shall be established for the purpose of assisting persons with insufficient means, reducing the educational disparity and promoting and improving the quality and efficiency of teachers for which the State shall allocate budget to such fund or use taxation measures or mechanisms, including providing a tax reduction to persons who donate properties into the fund, as provided by the law; such law shall, at least, prescribe that the management of the fund shall be independent and the fund shall be disbursed to implement such purpose.

Constitution of the Kingdom of Thailand, B.E. 2560 (2017) Section 71.

The State should strengthen the family unit which is an important basic element of society, provide appropriate accommodation, promote and develop the enhancement of health in order to enable people to have good health and strong mind, as well as promote and develop excellence in sports and to maximize the benefit for the people.

The State should promote and develop human resources to be good citizens with higher quality and abilities.

The State should provide assistance to children, youth, women, the elderly, persons with disabilities, indigent persons and underprivileged persons to be able to have a quality living, and shall protect such persons from violence or unfair treatment, as well as provide treatment, rehabilitation and remedies to such injured persons. (National Assembly of Thailand, 2017)

2) (Department of Children and Youth Provincial/Bangkok Child Protection Committee: Oversees law enforcement at the local level.)

Child Protection Act, B.E. 2546 (2003)

Child Protection Act, B.E. 2546 (2003) section 22 Treatment of the Child, in any case, shall give primary importance to the best interests of the Child and there shall not be unfair discrimination.

In determining if any act is for the best interests of or is discriminatory in an equitable nature to Child, considerations shall be made to the guidelines stipulated in the Ministerial Regulation.

Child Protection Act, B.E. 2546 (2003) section 23 Guardians shall care for, nurture, and develop a Child under their guardianship in a manner which is appropriate to such local traditions and culture, but which in any case shall not be below the minimum standards set by the Ministerial Regulation, and shall protect the welfare of the Child under their care against circumstances which may likely harm the physical or mental states.

Child Protection Act, B.E. 2546 (2003) section 26 Under the provisions of other laws, regardless of a Child's consent, a person shall not act as follows:

(1) to commit or omit acts which result in Torturing a Child's physical or mental state;

(2) to intentionally or negligently withhold things which are necessary to sustain life or health of a Child under his or her care to an extent which will likely cause physical or mental harm to the Child;

(3) to force, threaten, use, induce, or allow a Child to behave inappropriately or likely to be the cause of wrongdoing;

(4) to advertise by means of mass media or information dissemination to receive or give away a Child to any other person who is not the Child's relative, unless such action is done by the state or is approved by the state;

(5) to force, threaten, use, induce, allow, or act in any other way which results in a Child becoming a beggar, a vagrant, or an instrument for begging or committing crimes, or to act in any way which results in the exploitation of the Child;

(6) to use, employ, or ask a Child to work or act in such a way which will likely cause physical or mental harm, affect the growth, or hinder the Child's development;

(7) to force, threaten, use, induce, encourage, support, or allow a Child to play sports or commit any acts indicative of commercial exploitation in a manner which hinders the growth or development of a Child, or in manner which Tortures the Child;

(8) to use or allow a Child to gamble in any form or to enter into a gambling place, brothel, or other places where Children are not allowed;

(9) to force, threaten, use, induce, encourage, support, or allow a Child to perform or act in a pornographic manner, regardless of whether the intention is to obtain remuneration or for any purpose;

(10) to sell, exchange, or give liquor or cigarettes to a Child, unless it is for medical treatment.

If the offences under paragraph one carry heavier penalties under other laws, penalties under such law shall be imposed. (Ministry of Education, 2003)

3) (National Health Security Office)

National Health Security Act B.E.2545 (2002)

National Health Security Act B.E.2545 (2002) section 5 Every person shall enjoy the right to a standard and efficient health service as provided in this Act. (National Health Security Office, 2002)

4) (Social Security Office)

Social Security Act, B.E. 2533 (1990)

Social Security Act, B.E. 2533 (1990) section 33

An employee who is not younger than fifteen years of age and not older than sixty years of age, shall be an insured person.

When an employee, already an insured person under paragraph one, reaches sixty years of age and is still an employee of the employer subject to this Act, such employee shall continue to be deemed an insured person.

Social Security Act, B.E. 2533 (1990) section 40 Any other person who is not an employee under Section 33 may apply to be an insured person under this Act by expressing his or her intention to the Office.

Criteria and rate of contributions, type of benefits entitled to under Section 54 including criteria and conditions of benefit entitlement shall be prescribed in a Royal Decree.

Social Security Act, B.E. 2533 (1990) section 54 An insured person or a person under Section 73 shall be entitled to receive the benefits from the Fund, as follows

(1) injury or sickness benefits;

(2) maternity benefits;

(3) invalidity benefits;

(4) death benefits;

(5) child benefits;

(6) old-age benefits;

(7) unemployment benefits, except for an insured person under Section 39. (Ministry of Labour, 1990)

5) (Ministry of Education)

National Education Act B.E. 2542 (1999)

National Education Act B.E. 2542 (1999) section 10 In the provision of education, all individuals shall have equal rights and opportunities to receive basic education provided by the State for the duration of at least12 years. Such education, provided on a nationwide basis, shall be of quality and free of charge.

Persons with physical, mental, intellectual, emotional, social, communication, and learning deficiencies; those with physical disabilities; or the cripples; or those unable to support themselves; or those destitute or disadvantaged; shall have the rights and opportunities to receive basic education specially provided.

Education for the disabled in the second paragraph shall be provided free of charge at birth or at first diagnosis. These persons shall have the right to access the facilities, media, services, and other forms of educational aid in conformity with the criteria and procedures stipulated in the ministerial regulations.

Education for specially gifted persons shall be provided in appropriate forms in accord with their competencies.

National Education Act B.E. 2542 (1999) section 11 Parents or guardians shall arrange for their children or those under their care to receive compulsory education as provided by section 17 and as provided by relevant laws, as well as further education according to the families' capabilities.

National Education Act B.E. 2542 (1999) section 12 Other than the State, private persons and local administration organizations, individuals, families, community organizations, private organizations, professional bodies, religious institutions, enterprises, and other social institutions shall have the right to provide basic education as prescribed in the ministerial regulations.

National Education Act B.E. 2542 (1999) section 13 Parents or guardians shall be entitled to the following benefits:

(1) State support for knowledge and competencies in bringing up and providing education for their children or those under their care;

(2) State grants for the provision of basic education by the families for the children or those under their care as provided by the law;

(3) Tax rebates or exemptions for educational expenditures as provided by the law.

National Education Act B.E. 2542 (1999) section 14 Section 14 Individuals, families, communities, community organizations, private organizations, professional bodies, enterprises, and other social institutions, which support or provide basic education, shall be entitled to the following benefits as appropriate:

(1) State support for knowledge and competencies in bringing up those under their care;

(2) State support for the provision of basic education as provided by the law;

(3) Tax rebates or exemptions for educational expenditures as provided by the law.

National Education Act B.E. 2542 (1999) section 17 Compulsory education shall be for nine years, requiring children aged seven to enroll in basic education institutions until the age of 16 with the exception of those who have already completed grade 9. Criteria and methods of calculating children's age shall be as stipulated in the ministerial regulations.

National Education Act B.E. 2542 (1999) section 18 Early childhood and basic education shall be provided in the following institutions:

(1) Early childhood development institutions, namely: childcare centres; child development centres; preschool child development centres of religious institutions; initial care centres for disabled children or those with special needs, or early childhood development centres under other names.

(2) Schools, namely: state schools, private schools, and those under jurisdiction of Buddhist, or other religious institutions.

(3) Learning centres, namely: those organized by non formal education agencies; individuals; families; communities; community organizations; local administration organizations; private organizations; professional bodies; religious institutions; enterprises; hospitals; medical institutions; welfare institutes; and other social institutions. (Office of the Permanent Secretary, Ministry of Education, 1999)

6) (Department of Labour Protection and Welfare)

Labour Protection Act B.E. 2541 (1998)

Labour Protection Act B.E. 2541 (1998) section 16 An Employer, a chief, a supervisor, or a work inspector shall be prohibited from committing sexual abuse, harassment or nuisance against an employee.

Labour Protection Act B.E. 2541 (1998) section 44 An Employer shall not employ a child under fifteen years of age as an Employee.

Labour Protection Act B.E. 2541 (1998) section 45 In the case of employment of a young worker under eighteen years of age, the Employer shall comply with the following:

(1) notify a Labour Inspector regarding the employment of a young worker within fifteen days of the young worker commencing work;

(2) prepare a record of employment conditions in case of a change, taken place to be kept at the place of business or at the office of the Employer available for inspection by a Labour Inspector during working hours; and

(3) notify the Labour Inspector regarding the termination of employment of a young worker within seven days from the date of young worker being dismissed. The notification or the record under paragraph one shall be in accordance with the forms prescribed by the Director-General.

Labour Protection Act B.E. 2541 (1998) section 46 An Employer shall provide a rest period for a young worker of not less than one consecutive hour after the Employee has worked for not more than four hours; and during the period of such four hours, the young worker shall have rest periods as fixed by the Employer.

Labour Protection Act B.E. 2541 (1998) section 47 An Employer shall not require a young worker under eighteen years of age to work between 22.00 hours and 6.00 hours unless written permission is granted by the Director-General or a person entrusted by the Director-General.

The Employer may require a young worker under eighteen years of age who is a performer in film, theatre or other similar acts to work during such hours; provided that the Employer shall provide the young worker with proper rest periods.

Labour Protection Act B.E. 2541 (1998) section 48 An Employer shall not require a young worker under eighteen years of age to work overtime or to work on a Holiday. (Department of Labour Protection and Welfare, 2000)

Discussions

Research on legal measure in increasing birth rate promotion found that current Thai law in increasing birth rate promotion has been enforced for a long time, the provision related to these are inappropriate with current circumstances; 2) there is a problem of the lack of a primary agency directly responsible related in increasing birth rate promotion. This leads to Thailand facing a declining birth rate because overall, the decision to have children is based on the costs and expected benefits of having children and parents planning to have children must be prepared to dedicate almost all of their time to childcare and be ready to sacrifice money for various child expenses for at least 20 years. Therefore, measures should be in place to increase birth rates. This differs from the laws of Australia, which, children must receive an education while working and children cannot work during school hours and establishing a childcare center for working parents with minimal or no cost, and laws of the United States of America, which free education up to the bachelor's degree level, and educational institutions should be prohibited from charging any fees including free breakfast and lunch arrangement in school. As a result, these countries have more efficient in increasing birth rate promotion.

Summary of the Study

The study on legal measure in increasing birth rate promotion found that, although Thai law impose upon Prime Minister's Office Regulations Concerning Leave of Absence for Government Officials B.E. 2555 (2012), Royal Decree Medical Welfare Benefits B.E. 2553 (2010), Labour Protection Act B.E. 2541 (2000), Revenue Code, Constitution of the Kingdom of Thailand 2017, Child Protection Act, B.E. 2546 (2003), National Health Security Act B.E.2545 (2002), Social Security Act, B.E. 2533 (1990), National Education Act B.E. 2542 (1999), the existing legal measures and policies are not adequately addressing the needs to increase birth rates. The Constitution of the Kingdom of Thailand, B.E. 2560 (2017) section 48 provide that The rights of mothers during the period before and after

childbirth are protected and they receive assistance as prescribed by law, section 54 provide that The state must take steps to ensure that young children receive systematic care and have their quality of life improved and provide every child with 12 years of quality education, from preschool to the end of compulsory education, free of charge and section 55 provide that The state must guarantee the right of citizens to receive adequate public health services, including maternal and fetal care. However, subordinate legislation is insufficient to promote childbirth.

Recommendations

The recommendation and measure were found as follows:

1. Short Term Measures

1.1 The authors suggest that amendments in Labour Protection Act B.E. 2541 (2000) shall include changes related to law mandates that children must receive an education while working and children cannot work during school hours as guideline from Australia Law. (Queensland Government, 2006)

1.2 The authors suggest that amendments in National Education Act B.E. 2542 (1999) shall include changes related to free education up to the bachelor's degree level, and educational institutions should be prohibited from charging any fees including free breakfast and lunch arrangement in school as guideline from United States Law. (U.S. Government Information, 1966)

1.3 The authors suggest that amendments in Child Protection Act, B.E. 2546 (2003) shall include changes related to establishing a childcare center for working parents with minimal or no cost as guideline from Australia Law. (Australian Government Department of Education, 2022)

1.4 The authors suggest that amendments in Prime Minister's Office Regulations Concerning Leave of Absence for Government Officials B.E. 2555 (2012) and Labour Protection Act B.E. 2541 (2000) shall include changes related to paid maternity leave for one year and father took leave to raise his child for one year.

2. Long Term Measures

2.1 The authors suggest that new specific law for legal measure in increasing birth rate promotion including special treatment, for example, mothers should

receive free family planning and reproductive health counseling services. free prenatal checkups and childbirth expenses, and from birth, children should receive free health checkups and vaccinations against infectious diseases until they reach adulthood, child support allowance of 10,000 baht per month until age 25 years provision, 1 child receives a baby bonus of 100,000 baht and having 2 child receives a baby bonus of 100,000 baht and providing farmland for families with a third child, shall be introduced.

2.2 A systematic structure of authority, responsibilities, and law enforcement mechanisms should be established.

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A Structural Equation Model of Causal Factors Influencing Teachers' Instructional Management in the Thonburi University School Network, Thailand

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Abstract

This study aimed to examine a structural equation model of causal factors influencing teachers' instructional management and to investigate guidelines for promoting instructional management among teachers in the Thonburi University school network. The study employed a mixed-methods research design, incorporating both quantitative and qualitative approaches. The sample consisted of 392 teachers selected through cluster random sampling. The research instruments consisted of a questionnaire with a reliability coefficient of 0.97 and an interview protocol that had been validated for content validity, with a content validity index (IOC) of 1.00. Quantitative data were analyzed using descriptive statistics and partial least squares structural equation modeling (PLS-SEM), while qualitative data were analyzed using content analysis.

The findings revealed that the structural equation model demonstrated a good fit with the empirical data and explained a high proportion of variance in teachers' digital literacy and instructional management. Teachers' digital literacy exerted the strongest direct effect on instructional management and served as a key mediating variable between organizational contextual factors and instructional management. In addition, the proposed guidelines emphasized the development of supportive school environments and learning-oriented organizational cultures, together with the enhancement of digital literacy among teachers and students, to promote learner-centered instructional management aligned with societal changes and future labor market demands. These findings indicate that

improving teachers' instructional management within school network contexts should be primarily driven by strengthening teachers' digital literacy as a core mechanism.

Keywords: Structural Equation Modeling, Causal Factors, Teachers' Instructional Management, School Network

Introduction

Education is a crucial mechanism for human resource development, aiming to equip learners with knowledge, competencies, and desirable attributes necessary for quality living and effective participation in society. In the context of the rapidly changing 21st century, countries worldwide, including Thailand, have placed increasing emphasis on continuous educational development, with a focus on cultivating learners who are knowledgeable, critical thinkers, and capable of applying knowledge in practice. This approach has been implemented through the adaptation of instructional processes to align with societal changes, integrating active learning, modern technologies, and the ethical use of digital technologies in order to enhance learners' competencies and strengthen teachers' professional capacities for the 21st century (Office of the Education Council, 2017; Office of the Basic Education Commission, 2025). Teachers play a pivotal role in instructional management and the enhancement of educational quality by designing and implementing learning processes to achieve intended outcomes. Numerous studies have indicated that teachers' instructional management significantly influences students' academic achievement and engagement, underscoring teacher quality as a critical factor in students' educational success (Engida et al., 2024; Rudin et al., 2024). However, effective instructional management does not rely solely on teachers' individual capacities but also requires supportive contextual factors within schools, including the learning environment, organizational culture, and teachers' digital literacy.

The school environment is a key factor that facilitates instructional management, encompassing both the learning atmosphere and the availability of instructional resources. A supportive school environment influences teachers' instructional practices and students' learning outcomes, as it enables teachers to manage learning more effectively and enhances student engagement (Fraser, 2012; Khudadad & Mickelson, 2021). In addition,

organizational culture—reflected through shared values, practices, and institutional structures—plays a significant role in shaping teachers' work behaviors and instructional effectiveness. An organizational culture that supports learning and innovation can significantly enhance teachers' competencies and the effectiveness of instructional management (Daft, 2008; Tiwa Lowpasee & Jittirat Sangloetuthai, 2017). Furthermore, digital literacy is a critical competency for teachers in the 21st century. It encompasses the ability to use digital technologies, communicate effectively, think critically, and apply technology ethically. Teachers with high levels of digital literacy are better able to design and integrate technology into instructional management, thereby promoting student engagement and improving the overall effectiveness of the learning process (Ng, 2012; Hatlevik et al., 2015).

Although the Thonburi University School Network places emphasis on teachers' professional development and the promotion of digital literacy, practical implementation reveals several challenges. Some teachers still lack sufficient knowledge, skills, and confidence in using digital technologies for instructional management. In addition, schools-particularly private institutions-face constraints related to resources and budgets, which limit the effective integration of technology into teaching and learning processes. These findings are consistent with previous studies indicating that educational institutions often encounter limitations in resources, personnel, and infrastructure, thereby hindering the effective development of instructional management. Moreover, variations in teachers' knowledge and experience in instructional design and technology use result in limited diversity of learning activities. Inadequate systems for assessment, evaluation, and data management further exacerbate these challenges. Collectively, these factors constitute significant barriers to the effective development of instructional management (Supreeya Traiyakhan & Rachata Suvannagoot, 2022; Chuthamas Chomthong, 2025).

Based on the aforementioned issues, there is a clear need for an empirical investigation to systematically explain the causal relationships among school environment, organizational culture, and teachers' digital literacy influencing instructional management. Employing structural equation modeling allows for a comprehensive examination of these relationships. The findings of this study are expected to address existing knowledge gaps and provide practical guidelines for enhancing instructional management and

improving educational quality within the context of the Thonburi University School Network.

Content

1. Research Objectives

1.1 To examine a structural equation model of causal factors influencing teachers' instructional management within the Thonburi University School Network.

1.2 To explore guidelines for promoting teachers' instructional management within the Thonburi University School Network.

2. Research Hypotheses

H1: The school environment has a direct effect on teachers' instructional management.

H2: The school environment has a direct effect on teachers' digital literacy.

H3: Organizational culture has a direct effect on teachers' instructional management.

H4: Organizational culture has a direct effect on teachers' digital literacy.

H5: Teachers' digital literacy has a direct effect on teachers' instructional management.

3. Expected Contributions

This study provides a valid and robust structural equation model that explains the causal factors influencing teachers' instructional management. The findings and empirical evidence derived from this research offer valuable guidance for school administrators to apply in promoting and enhancing teachers' professional capacity in alignment with the specific contexts of their institutions. Ultimately, the results support the development of instructional management practices that effectively respond to learners' needs.

4. Conceptual Framework

The development of the conceptual framework was based on a synthesis of relevant literature, theories, and previous studies. School environment, organizational culture, and digital literacy were identified as latent variables influencing teachers' instructional management, drawing on the conceptual foundations proposed by Tableman

(2004), Daft (2008), and Hatlevik et al. (2015), respectively. Teachers' instructional management was conceptualized based on the framework of Terrell Shockley et al. (2024). Based on this conceptual framework, a structural equation model was developed to explain the causal relationships among the study variables. The proposed model was empirically tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), as illustrated in Figure 1.

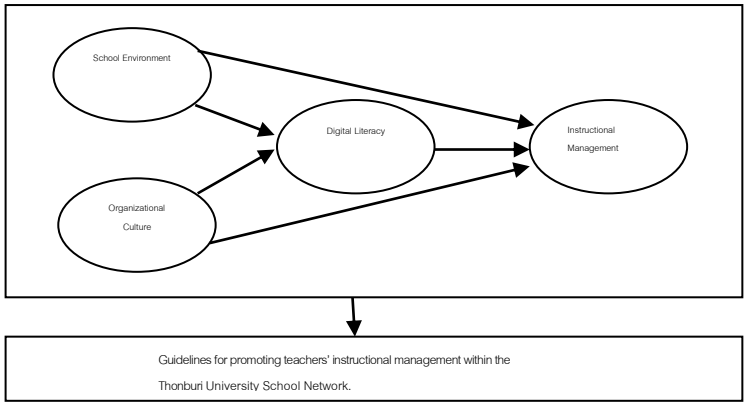


Figure 1. Research Conceptual Framework

5. Research Methodology

This study employed a mixed methods research design, integrating quantitative and qualitative approaches. The quantitative component focused on examining causal relationships among the study variables through Partial Least Squares Structural Equation Modeling (PLS-SEM) using the SmartPLS software. The qualitative component involved content analysis of data obtained from in-depth interviews, which was used to support, explain, and enrich the quantitative findings.

5.1 Population, Sample, and Key Informants

The population of this study consisted of 2,823 teachers from 28 schools within the Thonburi University School Network. The sample size was determined using Daniel Soper's sample size calculator for structural equation modeling, with an assumed effect size of 0.20, a statistical power of 0.80, four latent variables, and twelve observed variables. The calculation indicated a minimum required sample size of 339 participants. Cluster random sampling was employed by randomly selecting 14 schools, and the

sample size was increased to 392 teachers to account for potential data loss and to enhance the stability of statistical estimations.

The key informants for the qualitative component were five teachers from the Thonburi University School Network, selected through purposive sampling. The selection criteria included having at least five years of teaching experience and being recognized for effective instructional management within the school network.

5.2 Research Instruments

Two types of research instruments were employed in this study: a quantitative instrument in the form of a questionnaire and a qualitative instrument consisting of a structured in-depth interview guide. The details are as follows.

5.2.1 Questionnaire

The questionnaire was developed based on relevant concepts, theories, and previous studies. It consisted of a checklist and a five-point Likert-scale format. The questionnaire comprised four sections: (1) respondents' demographic information; (2) factors influencing teachers' instructional management, including school environment, organizational culture, and digital literacy; (3) teachers' instructional management, covering curriculum, teaching, and assessment and evaluation; and (4) open-ended questions soliciting suggestions regarding teachers' instructional management. Content validity was examined by a panel of experts, and the Item-Objective Congruence (IOC) index was calculated. Items with IOC values of 0.67 or higher were retained. The questionnaire was subsequently revised based on expert feedback and pilot-tested with 30 participants who were not part of the main sample. The overall reliability of the questionnaire was found to be 0.97.

5.2.2 Interview Instrument

The interview instrument was a structured in-depth interview designed to synthesize guidelines for promoting teachers' instructional management. The interview was divided into two sections as follows: (1) issues concerning opinions on the school environment, organizational culture, and digital literacy affecting teachers' instructional management in schools within the Thonburi University school network; and (2) issues concerning teachers' instructional management, covering curriculum, teaching and learning management, and measurement and evaluation. The interview questions

were examined for content validity by a panel of experts. Items with an Index of Item-Objective Congruence (IOC) value of 0.67 or higher were selected, and the items that met the criteria obtained an IOC value of 1.00. Subsequently, the questions were revised to enhance clarity and appropriateness before being used for actual data collection.

5.3 Data Collection

Data were collected from both secondary and primary sources. Secondary data were obtained through document research, including a review of relevant literature and previous studies, to inform the conceptual framework and identify causal factors influencing teachers' instructional management. Primary data were collected using questionnaires and structured in-depth interviews administered to the study sample and key informants.

5.4 Statistical Analysis

Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to analyze the quantitative data. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed using the SmartPLS software to assess both the measurement model and the structural model. Qualitative data obtained from in-depth interviews were analyzed using content analysis.

6. Research Results

Based on the examination of the structural equation model of causal factors influencing teachers' instructional management in the Thonburi University School Network, the research findings can be summarized as follows.

6.1 The results of the structural equation model analysis examining causal factors influencing teachers' instructional management in the Thonburi University school network include an assessment of the measurement model quality, an evaluation of discriminant validity using the Heterotrait-Monotrait (HTMT) criterion, and an analysis of the structural model. This also involves testing direct and indirect effects as well as the mediating role of the latent variables, as presented in Tables 1-3.

Table 1. Measurement Model Summary

Construct	CR	AVE
ENVI	0.953	0.646
CULT	0.967	0.728
DIGT	0.950	0.681
LEARN	0.927	0.595

From Table 1, the results indicate that the measurement model demonstrates very good quality for all latent constructs—school environment (ENVI), organizational culture (CULT), teachers' digital literacy (DIGT), and instructional management (LEARN). All constructs exhibit composite reliability (CR) values ranging from 0.927 to 0.967, exceeding the recommended threshold and indicating a high level of internal consistency. Furthermore, the average variance extracted (AVE) values for all constructs exceed 0.50, confirming adequate convergent validity.

Table 2. Heterotrait–Monotrait (HTMT) Matrix

Construct	ENVI	CULT	DIGT	LEARN
ENVI	-			
CULT	0.872	-		
DIGT	0.813	0.852	-	
LEARN	0.834	0.791	0.88	-

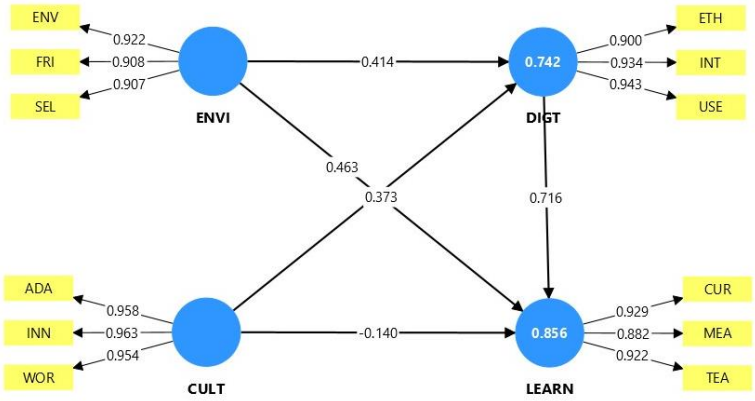
From Table 2, the HTMT values among all pairs of latent constructs range from 0.791 to 0.880, which are below the recommended threshold of 0.90 proposed by Henseler et al. (2016). These results indicate that the measurement model demonstrates an acceptable level of discriminant validity. Although the HTMT value for some construct pairs—particularly between teachers' digital literacy (DIGT) and instructional management (LEARN)—is relatively high (HTMT = 0.880), it does not exceed the recommended cutoff. This finding suggests that the latent constructs remain conceptually distinct. Moreover, the relatively high HTMT value between DIGT and LEARN is consistent with the results of the structural model analysis, which revealed that DIGT has a strong direct effect on LEARN. Overall, the measurement model exhibits adequate quality and is appropriate for subsequent structural equation modeling analysis.

Table 3. Structural Model Results

Independent Variable	Dependent Variable	Direct Effect (β)	Indirect Effect	Total Effect	f^2	t	p	R^2
ENVI	DIGT	0.414	-	0.414	0.089	2.489*	0.013	0.74
CULT	DIGT	0.463	-	0.463	0.112	2.729*	0.006	
ENVI	LEARN	0.373	0.296	0.669	0.119	3.935**	0.000	0.85
CULT	LEARN	-0.140	0.332	0.192	0.016	1.116	0.264	
DIGT	LEARN	0.716	-	0.716	0.917	8.361**	0.000	

Note: β = standardized path coefficient; f^2 = effect size; R^2 = coefficient of determination of endogenous constructs. *p < .05, *p < .01.

From Table 3, the structural equation model explains 74% of the variance in teachers' digital literacy (DIGT) and 85% of the variance in instructional management (LEARN), both of which are considered high, indicating a good overall explanatory power of the model. The path analysis results reveal that teachers' digital literacy has a very strong direct effect on instructional management (β = 0.716, p < .001) and represents the most influential factor in the model. In addition, both school environment (ENVI) and organizational culture (CULT) exert significant direct effects on teachers' digital literacy. Moreover, school environment has a significant direct effect on instructional management, whereas organizational culture does not exhibit a significant direct effect on instructional management. These findings suggest that teachers' digital literacy functions as a key causal mechanism mediating the influence of organizational context on instructional management. The structural model is illustrated in Figure 2.



SRMR = 0.051, d_ULS = 0.207, d_G =0.434 ,Chi-square 232.470, 0.850

Figure 2. Causal Factor Model Influencing Teachers' Instructional Management in the Thonburi University School Network

6.2 Results on Guidelines for Promoting Teachers' Instructional Management in the Thonburi University School Network

6.2.1 School Environment

The informants emphasized that both indoor and outdoor learning environments should be designed to be safe, supportive of learning, and conducive to positive interactions with students. They suggested providing students with opportunities to exercise autonomy in choosing learning activities aligned with their interests, taking individual developmental differences into account, and promoting experiential, student-centered learning practices.

6.2.2 Organizational Culture

The informants reached a consensus that organizational culture should encourage teachers' autonomy in designing and implementing instructional practices. Such a culture should support participation, open communication, the exchange of ideas, and learning from mistakes. In addition, clearly defined roles and responsibilities were viewed as essential for enhancing the effectiveness of teachers' instructional management.

6.2.3 Digital Literacy

A key issue highlighted by the informants was the development of digital literacy among both teachers and students. They emphasized the importance of supporting the use of technology as a learning tool alongside the development of self-directed learning skills. Furthermore, fostering constructive, safe, and responsible communication in digital environments was identified as a critical component of digital literacy development.

6.2.4 Teachers' Instructional Management

The informants suggested that instructional management should be aligned with labor market demands and ongoing changes in Thai society. Instruction should aim to develop students' adaptability, career readiness, and life skills for the future. This approach should emphasize student-centered learning, active learning strategies, the integration of theory with real-world practice, and assessment practices that support continuous improvement. These findings reflect the necessity of redefining teachers' roles to align with societal transformation and the evolving world of work.

7. Discussion

Based on the results of the statistical hypothesis testing, the findings can be discussed in relation to the research objectives as follows.

7.1 Structural Equation Model of Causal Factors Influencing Teachers' Instructional Management in the Thonburi University School Network

The results of the structural model fit assessment indicated that the SRMR value was 0.051, which is below the recommended threshold of 0.08 and close to the more stringent criterion of 0.05. This suggests that the model exhibits a low level of overall discrepancy. In addition, the d_ULS and d_G values were lower than the upper bounds obtained from the bootstrapping analysis at both the 95% and 99% confidence levels, indicating that the model demonstrates a good fit with the empirical data according to the PLS-SEM guidelines (Hair et al., 2019; SmartPLS, n.d.). Regarding the explanatory power of the model, the school environment and organizational culture jointly explained 74% of the variance in teachers' digital literacy ($R^2 = 0.74$). Meanwhile, the school environment, organizational culture, and teachers' digital literacy together accounted for as much as 85% of the variance in teachers' instructional management ($R^2 = 0.85$), which is considered a very high level according to the criteria proposed by Hair et al. (2019). These findings indicate that the developed structural equation model has strong explanatory power in elucidating the causal relationships among the studied variables.

The causal path analysis revealed that both the school environment and organizational culture exerted significant positive effects on teachers' digital literacy. This finding is conceptually consistent with prior studies highlighting the influence of organizational and school-related factors on teachers' ICT-related practices and work outcomes, which emphasize the critical role of school context and organizational culture in fostering teachers' technological competencies (Ferede et al., 2022; Erdem et al., 2025). Moreover, teachers' digital literacy demonstrated a strong direct effect on instructional management. This finding aligns with previous studies (Ngao, 2025; Yetis, 2025), which reported that teachers' digital competencies are key factors facilitating instructional design, the integration of technology into teaching and learning, and the enhancement of students' learning quality.

The mediation analysis further indicated that teachers' digital literacy partially mediated the relationship between the school environment and teachers' instructional management, while fully mediating the relationship between organizational culture and teachers' instructional management. These results suggest that organizational culture cannot directly influence teachers' instructional management unless it is translated into practical competencies through teachers' digital literacy. This finding is consistent with the systems perspective proposed by Henseler (2016), which posits that contextual factors tend to influence outcomes through process mechanisms rather than through direct effects.

7.1.1 The findings revealed that the school environment had a statistically significant direct effect on teachers' instructional management in the schools within the Thonburi University network. This indicates that an appropriate school environment plays a crucial role in supporting and enhancing the quality of teachers' instructional management. This result is consistent with the study of Seddhawudh Thadasirithanasakoon (2024), which found that the school environment directly influences teachers' instructional management through multiple dimensions, including resources and materials, the organization of learning spaces that facilitate instructional activities, the availability of diverse learning resources, and opportunities for professional development such as training programs, seminars, and collaborative learning within the organization. These findings suggest that when schools provide a supportive learning environment in both physical and social dimensions, teachers are better able to design and implement effective instructional practices. This conclusion is in line with Tony (2019), who noted that effective management of school facilities and infrastructure has a direct impact on the quality of teaching and learning. Furthermore, the conceptual framework proposed by Wisana Abdulloh and Wuttichai Niemted (2020) helps explain the present findings by emphasizing that effective instructional management is a key component of 21st-century learning, as the role of teachers has shifted from knowledge transmitters to learning facilitators. This role transformation requires learning environments that support hands-on learning, self-directed knowledge construction, and the holistic development of learners.

7.1.2 The findings indicated that the school environment had a statistically significant direct effect on teachers' digital literacy in the schools within the Thonburi University network. This result highlights that a learning environment supportive of learning and technology use plays a crucial role in enhancing teachers' digital knowledge, understanding, and skills. This finding is consistent with the study of Rasdiana et al. (2024), which demonstrated that the school environment exerts a direct influence on teachers' digital literacy, and that such digital literacy subsequently affects the effectiveness of instructional management. The present results further support the proposition that teachers' digital literacy should not be viewed merely as an individual competence, but rather as an outcome shaped by a supportive organizational context and working environment. This perspective is aligned with the study of Pisut Srichan (2019), which found that institutional support for technology enables teachers to access and continuously use digital tools, thereby contributing to the development of students' digital skills through teachers' instructional practices. Moreover, the conceptual framework proposed by Aekkaphob Intarapoo and Panita Wannapiroon (2021) helps explain the findings of this study by emphasizing that the provision of an intelligent digital learning environment plays a vital role in promoting learning, facilitating interaction between teachers and learners, and enabling timely problem-solving in instructional processes. These conditions are essential for fostering teachers' digital literacy within the school context.

7.1.3 The findings revealed that organizational culture did not have a statistically significant direct effect on teachers' instructional management in the schools within the Thonburi University network, which was inconsistent with the proposed hypothesis. However, the mediation analysis indicated that organizational culture exerted a statistically significant indirect effect on teachers' instructional management through teachers' digital literacy, with an indirect effect value of 0.332, indicating full mediation. These results suggest that organizational culture alone cannot directly influence teachers' instructional management unless it is translated into practical competencies through teachers' digital literacy. In other words, organizational values, policies, or climate by themselves may be insufficient to bring about changes in instructional practices if teachers lack the necessary digital knowledge, understanding, and skills to effectively integrate technology into teaching and learning. This finding is

consistent with the perspective of Tanavich Sudngulueam (2025), who argued that digital transformation leads to changes in school organizational structures and values; however, such influences do not typically manifest directly at the level of instructional practices, but rather through the development of teachers' capacities and competencies, particularly digital literacy. Moreover, the present findings align with the study of Setyawan et al. (2022), which found that supportive, achievement-oriented, and collaborative school cultures significantly enhance teachers' digital skills and digital knowledge. These digital competencies, in turn, have a direct impact on teaching effectiveness and function as a mediating mechanism linking school culture to teachers' instructional management outcomes.

7.1.4 The findings indicated that organizational culture had a statistically significant direct effect on teachers' digital literacy in the schools within the Thonburi University network. This suggests that organizational values, practices, and the working climate that support learning and technology use play a crucial role in enhancing teachers' digital capacity. This finding is consistent with the study of Rasdiana et al. (2024), which reported that school culture has a significant influence on teachers' digital skills and digital knowledge, particularly cultures that promote collaborative learning, knowledge sharing, and innovation. In contrast, rigid or highly hierarchical cultures may constrain the development of such competencies. Furthermore, the results support the proposition that teachers' digital skills and digital knowledge function as a key mechanism linking the influence of organizational culture to teachers' work outcomes and instructional management. This is consistent with the findings of Seddhawudh Thadasirithanasakoon (2024), who found that organizational culture exerts a statistically significant direct effect on teachers' digital literacy. From a theoretical perspective, Schein's (2010) concept of organizational culture explains that culture emerges from shared learning experiences among organizational members and serves to shape collective assumptions, values, and work practices, thereby influencing patterns of learning and the development of personnel competencies. At the same time, the perspective of Kanokkan Noipoung (2024) emphasizes that the development of teachers' digital skills requires collaborative learning, teamwork, and learning motivation, highlighting

the importance of an organizational culture that systematically supports the enhancement of teachers' digital capacity.

7.1.5 The findings revealed that teachers' digital literacy had a statistically significant direct effect on instructional management among schools in the Thonburi University network. This indicates that teachers' levels of digital knowledge, understanding, and technological skills play a direct role in their ability to implement the curriculum, design learning activities, and effectively assess student learning outcomes. This finding is consistent with Paetsch et al. (2023), who reported that information and communication technology (ICT) literacy influences teachers' confidence in integrating technology into instruction and has a direct effect on the actual use of technology in the teaching and learning process. In addition, Raave et al. (2024) emphasized that effective technology integration in teaching does not depend solely on the availability of technological tools, but rather on teachers' ability to select and apply technologies in ways that align with instructional objectives and learning goals. Accordingly, the present study suggests that teachers with higher levels of digital literacy are better able to make informed decisions regarding the appropriate selection and application of digital technologies, which serves as a key mechanism through which digital literacy directly enhances the quality of instructional management. This finding is further supported by the framework proposed by Jurarat Thammaprateep (2016), who argued that high-quality learning management in the digital era requires the integration of content knowledge, pedagogical knowledge, and technological knowledge, as conceptualized in the TPACK framework. In particular, technological knowledge and skills constitute a foundational component for designing and implementing effective learning activities. If teachers possess limitations in digital competence, instructional management may fail to achieve its intended outcomes, even when content knowledge and pedagogical approaches are appropriate.

7.2 Guidelines for Promoting Teachers' Instructional Management in the Thonburi University School Network

The qualitative analysis of data obtained from key informants indicates that promoting teachers' instructional management requires an integrated approach across three main dimensions: the school environment, organizational culture, and teachers' digital literacy. This integrated development is essential to support flexible, high-quality

instructional management that can effectively respond to societal changes in the digital era. These guidelines are consistent with the results of the structural equation modeling (PLS-SEM) analysis, which revealed that the three factors exert different patterns of influence on teachers' instructional management. Specifically, the school environment has both direct and indirect effects on instructional management, whereas organizational culture influences instructional management only through teachers' digital literacy. Moreover, teachers' digital literacy was found to be the factor with the strongest and most statistically significant direct effect on instructional management. These findings highlight the role of digital literacy as a key causal mechanism linking contextual factors within educational institutions to teachers' actual instructional practices. This is consistent with the teacher development framework for education in the digital era proposed by Dusadee Sarabut and Banjong Lawalee (2025), who argued that teachers in the 21st century must possess digital skills and the ability to design technology-integrated learning experiences, while acting as facilitators of learning and creating environments that promote active learning. Furthermore, the finding that organizational culture does not have a direct effect on teachers' instructional management helps explain that the transformation of teachers' roles into learning facilitators cannot be achieved solely through policy-oriented values or organizational-level guidelines. Instead, it requires teachers' digital competence as a crucial practical mechanism for translating conceptual principles into actual instructional practices. This interpretation aligns with Phantharakphong and Liyanage (2026), who pointed out that Thailand's teacher development system tends to emphasize compliance with policy requirements rather than development that responds to teachers' real instructional contexts, resulting in a gap between policy objectives and teachers' professional needs in practice.

8. Recommendations

8.1 Practical and Policy Implications

Based on the research findings indicating that teachers' digital literacy functions as the central mechanism through which the school environment and organizational culture influence teachers' instructional management, the following recommendations are proposed for school administrators, supervising agencies, network administrators, and teachers.

8.1.1 Policy implications for school administrators and supervising agencies

School administrators and supervising agencies should prioritize the systematic development of teachers' digital literacy by establishing clear policies that position digital literacy as a core competency within professional teaching standards. Such policies should be explicitly linked to performance appraisal systems and continuous professional development frameworks. In addition, adequate budget allocation and resource provision are essential to support technological infrastructure, including internet connectivity, digital learning platforms, and technical support systems. These measures will help create an enabling environment that facilitates the effective use of digital technologies and supports the sustainable development of teachers' digital literacy, thereby enhancing instructional management in practice.

8.1.2 Practical implications for network administrators

Network administrators should design academic programs and community service initiatives that emphasize the development of practical digital competencies rather than focusing solely on theoretical training. Professional development activities should be organized through collaborative learning approaches, such as digital professional learning communities (PLCs), coaching and mentoring systems, and the systematic exchange of best practices in technology-integrated instructional management. These approaches can strengthen teachers' hands-on digital skills and promote the effective application of digital technologies in instructional practices.

8.1.3 Practical implications for teachers

Teachers should engage in continuous self-development across three core dimensions of digital literacy: (1) the effective use of digital technologies for instructional purposes; (2) critical thinking and the evaluation of digital information; and (3) ethical and responsible use of digital technologies. Strengthening these competencies will enable teachers to design and implement instructional activities that effectively respond to learners' needs in the digital era and enhance the quality of instructional management.

8.2 Recommendations for Future Research

Given the findings that organizational culture does not directly influence teachers' instructional management but exerts its effects through teachers' digital literacy, the following recommendations are proposed for future research.

8.2.1 Future studies should investigate the underlying mechanisms or intervening factors through which organizational culture is translated into instructional practices. Potential factors include instructional leadership, teacher professional development systems, and teachers' motivation to integrate digital technologies into teaching and learning processes.

8.2.2 Future research should expand the scope of the sample to include diverse educational contexts, such as schools under different administrative authorities, non-formal and informal education centers, special education institutions, and early childhood development centers. In addition, incorporating moderating variables-such as teaching experience, grade level, or subject area-would provide deeper insights into contextual and group-level differences in the relationships among the study variables.

Conclusion

The quantitative findings from the structural equation modeling analysis of causal factors influencing teachers' instructional management in the Thonburi University School Network confirmed that the developed structural equation model demonstrated a high level of consistency with the empirical data. Teachers' digital literacy emerged as the most influential causal mechanism exerting a direct effect on teachers' instructional management and functioning as a key mediating variable through which the effects of the school environment and organizational culture were transmitted to teachers' instructional management. Although organizational culture did not have a direct effect on teachers' instructional management, it exerted a statistically significant indirect effect through the development of teachers' digital literacy. In contrast, the school environment influenced teachers' instructional management through both direct and indirect pathways.

The qualitative findings derived from the investigation of guidelines for promoting teachers' instructional management, based on the perspectives of key informants, were

consistent with the quantitative results. The informants emphasized the importance of establishing learning environments conducive to learning, fostering an organizational culture that supports collaborative learning, and enhancing teachers' digital competencies alongside the adaptation of instructional management practices to align with societal contexts and future labor market demands. These findings reflect that the development of teachers' instructional management requires an integrated approach at both the individual and organizational levels.

In conclusion, this study indicates that enhancing the quality of teachers' instructional management within the Thai educational context requires prioritizing the development of teachers' digital literacy as a central focus, in parallel with the systematic development of organizational contexts and learning environments within schools. Such an approach is likely to generate positive impacts on instructional effectiveness, student learning quality, and schools' readiness to adapt to changes in the digital society. However, if educational institutions emphasize policy formulation or the establishment of organizational culture without a serious commitment to developing teachers' digital competencies, policy-driven changes may fail to translate into concrete instructional practices, potentially resulting in a lack of continuity and long-term sustainability in the development of instructional management.

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An Analysis of Digital Technology Adoption and Its Impact on College Students' Purchase Intentions for Cultural and Creative Products in Guangxi, China

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Abstract

With the rapid development of mobile internet, e-commerce, and digital platforms, the digital economy has profoundly reshaped the cultural consumption landscape. Focusing on college students in Guangxi, China, this study empirically examines how digital technology adoption influences their purchase intention toward cultural and creative products (CCPs). Drawing on the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), and Cultural Identity Theory, a quantitative survey was conducted, yielding 389 valid responses. Data were analyzed using descriptive statistics and multiple regression analysis. The results indicate that perceived ease of use, facilitating conditions, hedonic motivation (from TAM/UTAUT2), perceived compatibility, observability (from IDT), and cultural knowledge (from Cultural Identity Theory) significantly and positively affect students' purchase intention. The model explains 21.5% of the variance in purchase intention. By integrating technological, innovative, and cultural-psychological factors into a unified framework, this study provides theoretical insights and practical implications for universities, cultural enterprises, and policymakers seeking to promote sustainable development of the cultural and creative industry in the digital economy era.

Keywords: Digital Technology Adoption; Cultural and Creative Products; Purchase Intention; College Students; Guangxi Province.

Background and Statement of the problem

In the digital economy era, the rapid development of technologies such as mobile Internet and e-commerce has promoted the digital transformation of the cultural and creative industry. China's digital service trade share has grown significantly, and the government's series of digital economy policies have provided strong support for the integration of CCPs with digital technology. As a multi-ethnic autonomous region in southwest China, Guangxi has rich ethnic cultural resources, which lay a solid foundation for the development of CCPs (Yan, 2024). In recent years, local cultural and creative consumption has shown a trend of online development, with younger groups represented by college students becoming the core consumer force.

College students, as "digital natives," are familiar with online platforms and their consumption behavior is deeply influenced by digital technology, tending to pursue personalized and experiential cultural consumption (Suliman et al., 2025). However, existing studies on cultural and creative product consumption mostly focus on developed eastern regions or Han college students, with insufficient attention to ethnic minority areas like Guangxi. Meanwhile, although some studies mention the application of digital technology in CCPs, they fail to systematically clarify the mechanism of how digital technology affects college students' acquisition of product information, formation of purchase intention and subsequent purchase behavior.

Against this background, two core research questions are proposed: First, what are the perceived levels and relative importance of technology acceptance, perceived innovation characteristics, and cultural identity among Guangxi college students when purchasing CCPs? Second, how do technology acceptance, perceived innovation, and cultural identity affect college students' purchase intention of CCPs individually and jointly, and are there interaction effects among these factors? Answering these questions is crucial for promoting the sustainable development of the cultural and creative industry in ethnic minority areas under the digital economy.

Objective

OJ1: To examine the level and importance of key factors, including technology acceptance cognition, perceived innovation characteristics, and cultural identity, in shaping purchase intentions for CCPs among college students in Guangxi.

OJ2: To investigate the causal impact and interplay of digital technology adoption factors (technology acceptance and innovation characteristics) and cultural identity on the purchase intention of college students.

Expected benefits

1) Theoretical Benefits

This study enriches the theoretical system of digital cultural consumption by integrating the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), and Cultural Identity Theory into a unified empirical framework. It addresses the research gap of insufficient integration of individual-level technical acceptance, perceived innovation, and cultural identity in existing literature, especially in the context of ethnic minority areas, and expands the application scenarios of these theories in the field of CCPs. By reinterpreting core constructs like perceived usefulness and perceived compatibility in a cultural context, it reveals the particularity of digital technology's impact on cultural consumption behavior and provides empirical support for cultural identity as an independent determinant of purchase intention in digital environments.

2) Practical Benefits

The research findings offer actionable insights for cultural and creative enterprises, universities, and policymakers in Guangxi and similar regions. Cultural and creative enterprises can optimize digital platform usability, design products aligned with college students' aesthetic and lifestyle preferences, and strengthen cultural element display to enhance purchase intention. Universities can integrate local ethnic cultural content into teaching and campus activities to boost students' cultural identity and indirectly promote cultural consumption. Policymakers can leverage digital economy strategies to support cultural innovation, talent training, and the sustainable development of the regional cultural industry, while the research framework and conclusions can serve as a reference for cultural and creative industry development in other ethnic minority areas.

Conceptual Framework

1. Conceptual Framework

This study proposes a concise conceptual framework to explore the impact of digital technology adoption on the purchase intention (PI) of cultural and creative products (CCPs) among Guangxi college students. The study hypothesizes that three core independent variables---Digital Technology Adoption (DTA), Perceived Innovative Characteristics (PIC), and Cultural Identity (CI)---have a direct positive impact on the dependent variable (PI).

Theory I: Technology Acceptance Model (TAM) and UTAUT2

TAM, proposed by Davis (1989), considers perceived usefulness and perceived ease of use as the core antecedents of technology adoption. The UTAUT2 model, after expansion, incorporates social influence, facilitating conditions, and hedonic motivation to adapt to different consumer behavior scenarios. Recent studies continue to validate and extend these frameworks in various digital consumption contexts, including e-commerce and social media platforms (Belmonte et al., 2024). Digital technology adoption is operationalized using the five dimensions of the Extended Technology Acceptance Model (TAM/UTAUT2): perceived usefulness (PU), perceived ease of use (PEOU), social impact (SI), facilitating conditions (FC), and hedonic motivation (HM). These dimensions constitute "digital technology adoption," exploring how the digital innovation attributes of cultural products (CCPs) enhance purchase intention.

Theory II: Diffusion of Innovation Theory (IDT)

Rogers (2003) emphasized five innovation attributes influencing the speed of adoption. Contemporary research has applied and refined these attributes in digital and cultural product contexts (Ngian et al., 2025). This study focuses on measuring three key dimensions of cultural products: perceived compatibility (PC), trialability (TRIAL), and observability (OBS). Recent empirical evidence confirms that compatibility and observability significantly influence user acceptance and intention to use innovative technologies (Jeong et al., 2024). These dimensions explore how the digital innovation attributes of cultural products (CCPs) enhance purchase intention.

Theory III: Cultural Identity Theory

Cultural identity refers to an individual's psychological sense of belonging to a particular cultural group, encompassing cognitive, affective, and behavioral dimensions. Recent research demonstrates that cultural identity plays a crucial mediating role in converting value perception into purchase intention for cultural products (Wang & Chung, 2025). Studies also show that cultural identity influences consumer attitudes and behavioral intentions in culturally themed consumption contexts. This study uses three dimensions---cultural knowledge (CK), category labeling (CL), and social connection (SC)---to explain the independent role of cultural factors in digital consumption.

Purchase Intention: This refers to students' purchase intentions of CCPs incorporating Guangxi ethnic cultural elements through digital platforms.

This framework clarifies how technological, innovative, and cultural psychological factors synergistically influence young consumers' purchasing decisions in the digital cultural consumption environment.

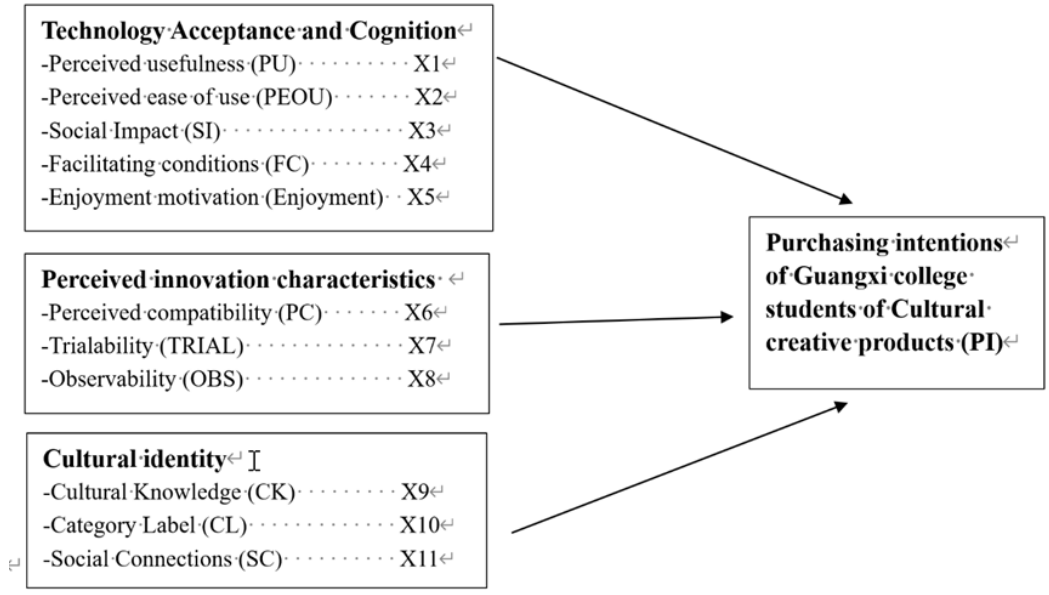


Figure 1: Conceptual Framework

Solid line: Direct positive effect

Research Methodology

This study adopted a quantitative cross-sectional design to explore the impact of digital technology adoption on Guangxi college students' purchase intention CCPs. Using

stratified random sampling, 400 questionnaires were distributed among undergraduates from 5 representative universities in Guangxi, yielding 389 valid responses. The structured questionnaire measured four core constructs (digital technology adoption, perceived innovation characteristics, cultural identity, purchase intention) with established scales (Cronbach's α > 0.7 for all dimensions). Data was analyzed via SPSS 27.0, including descriptive statistics, reliability/validity tests, Pearson correlation analysis, multicollinearity checks, and multiple linear regression to test hypotheses, ensuring rigorous statistical validity.

Research Results

Empirical results reveal that Guangxi college students' purchase intention for CCPs is at a moderate level regarding digital technology acceptance and adoption, perceived innovation characteristics, and cultural identity.

Table 1: Descriptive statistics on variables

Variables	$\bar{x}$	SD	Rating
Digital Technology Acceptance and Adoption			
Perceived usefulness	2.981	1.113	Neutral
Perceived ease of use	2.914	1.121	Neutral
Social impact	2.882	1.102	Neutral
Facilitating conditions	2.901	1.144	Neutral
Enjoyment motivation	2.912	1.103	Neutral
Total	2.919	0.786	Neutral
Perceived innovation characteristics			
Perceived Compatibility	2.908	1.175	Neutral
Trialability	2.949	1.167	Neutral
Observability	2.907	1.186	Neutral
Total	2.920	0.861	Neutral
Cultural identity			
Cultural Knowledge	2.899	1.152	Neutral
Category Label	2.943	1.114	Neutral
Social Connections	2.917	1.162	Neutral
Total	2.919	0.840	Neutral
Purchase Intention	2.856	1.161	Neutral
Total	2.856	1.161	Neutral

Table 2: Summary of Research Results

Model	R	R Square	Adjusted R square	Std. Error of the estimate
1	0.470	0.221	0.215	1.029

Table 3: ANOVA result of the research

Model	Sum of Squares	df	Mean Square	F	Sig
1Regression	115.604	3	38.535	36.422	.000
Residual	407.334	385	1.058		
Total	522.938	388			

The research model demonstrates relatively acceptable predictive accuracy. Analysis of variance (ANOVA) yields a p-value of 0.000 ($p < 0.05$) at the 0.05 significance level, indicating that the included independent variables are appropriate for explaining and predicting the purchase intention of the target group.

Table 4: Results of Research Hypothesis Testing

Hypothesis	Accept	Reject
H1a: Perceived usefulness is positive associated with Guangxi college students' purchase intention of cultural and creative products.		✓
H1b: Perceived ease of use exerts a positive effect on Guangxi college students' purchase intention of cultural and creative products.	✓	
H1c: Social impact has a positive influence on Guangxi college students' purchase intention of cultural and creative products.		✓
H1d: Facilitating conditions are positive related to Guangxi college students' purchase intention of cultural and creative products.	✓	
H1e: Enjoyment motivation is a positive determinant of Guangxi college students' purchase intention of cultural and creative products.	✓	
H2a: Perceived compatibility positive affects Guangxi college students' purchase intention of cultural and creative products.	✓	
H2b: Trialability is positive associated with Guangxi college students' purchase intention of cultural and creative products.		✓
H2c: Observability has a significant positive impact on Guangxi college students' purchase intention of cultural and creative products.	✓	

Hypothesis	Accept	Reject
H3a: Cultural knowledge positive influences Guangxi college students' purchase intention of cultural and creative products.	✓	
H3b: Category label exerts a positive effect on Guangxi college students' purchase intention of cultural and creative products.		✓
H3c: Social connection is positive related to Guangxi college students' purchase intention of cultural and creative products.		✓

With digital technology acceptance and adoption (TAC), perceived innovation characteristics (PIC), and cultural identity (CI) as independent variables, and purchase intention (PI) as the dependent variable, the model is validated, with the regression equation being

$$PI = 0.369 + 0.416(TAC) + 0.274(PIC) + 0.161(CI) + \epsilon.$$

Summary of the Study

This study investigates the impact of digital technology adoption on Guangxi college students' purchase intention toward CCPs. Using a quantitative approach with 389 valid questionnaires, the research integrates the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), and Cultural Identity Theory to examine how technological, innovative, and cultural factors jointly shape consumer behavior. The findings reveal that perceived ease of use, facilitating conditions, hedonic motivation, perceived compatibility, observability, and cultural knowledge are significant positive predictors of purchase intention, collectively explaining 21.5% of its variance. These results highlight the complementary roles of digital empowerment and cultural meaning in driving young consumers' engagement with CCPs. The study offers both theoretical contributions—by extending established adoption theories into the cultural product context—and practical implications for designing digital platforms, enhancing cultural education, and formulating policies to foster the sustainable growth of the cultural and creative industry in ethnic minority regions like Guangxi.

Discussions

This study's detailed findings reveal that digital cultural consumption is not driven by a single mechanism but by the interaction between technological efficiency, experiential value, and cultural meaning. The following discussion expands on these mechanisms, integrating empirical evidence with existing theoretical perspectives.

Within the technology acceptance dimension, perceived ease of use significantly influences purchase intention, indicating that user-friendly interfaces reduce cognitive effort and allow students to focus more on cultural content rather than system operation (Intra et al., 2024). This finding aligns with the broader technology acceptance literature, which consistently identifies ease of use as a critical enabler of initial adoption and sustained engagement (Davis, 1989). For digital-native college students, intuitive platform design lowers the cognitive cost of navigation, enabling them to allocate more attention to the cultural narratives embedded in the products. Facilitating conditions also positively shape purchase intention, providing institutional assurance for digital cultural consumption (Strzelecki, 2024). In the Guangxi context, where digital infrastructure varies across urban and rural areas, reliable platforms, stable internet connectivity, and accessible customer support serve as essential prerequisites that reduce transaction anxiety and build trust among student consumers. Enjoyment motivation reflects the extent to which digital platforms provide engaging cultural experiences, thereby stimulating students' interest and purchase intentions (Zhao et al., 2024). This finding supports the view that cultural consumption in digital environments is not purely utilitarian; rather, the experiential and hedonic dimensions—such as interactive features, immersive content, and aesthetic design—play a decisive role in converting passive browsing into active purchase behavior.

Regarding perceived innovation characteristics, perceived compatibility emerges as a strong predictor, as CCPs that match students' preferences and cultural orientations are more readily accepted (Abubakari et al., 2024). This suggests that the alignment between product design and consumers' existing value systems is particularly salient in culturally infused consumption contexts. For Guangxi students, cultural and creative products that authentically integrate local ethnic elements—such as Zhuang brocade patterns or bronze drum motifs—while resonating with contemporary aesthetics, are more likely to be perceived as personally relevant and therefore desirable. Observability

also positively impacts intention, as products that can be displayed or shared on digital platforms are more attractive to students (Karmaker, 2025). This finding underscores the socially expressive function of cultural consumption: when products are designed to be visually distinctive and shareable, they serve as a form of social currency, enabling students to communicate their cultural identity and taste to peer networks on platforms such as Xiaohongshu or WeChat Moments. However, trialability does not have a significant effect, suggesting that digital previews may not be critical for this product category (Theocharis et al., 2025). One plausible explanation is that cultural and creative products are often low-involvement, emotionally driven purchases where perceived purchase risk is relatively low. Consequently, the availability of trial features—such as "try now, pay later"—may not meaningfully alter purchase decisions compared to higher-involvement categories like electronics or durable goods.

Within cultural identity, cultural knowledge enhances students' appreciation of cultural meanings, increasing emotional resonance and purchase intention. This finding is consistent with prior research demonstrating that consumers with deeper cultural understanding exhibit stronger emotional attachment and willingness to support culturally meaningful products (Zong et al., 2023). When students possess knowledge about the historical background or craftsmanship behind a product, they are more likely to perceive it as authentic and valuable, thereby strengthening their intention to purchase. Category labels help students quickly identify cultural attributes and product value, facilitating purchase intention. However, the limited strength of this relationship suggests that while labeling serves as an informational cue, it may be less influential than deeper cultural knowledge or experiential engagement. Social connections reflect the importance of community interaction and emotional bonding in digital cultural consumption, thereby strengthening purchase intention (Hyun et al., 2022). This finding aligns with the view that cultural consumption often functions as a socially embedded practice, where purchasing behavior is reinforced by a sense of belonging to a community of like-minded peers.

By integrating technology adoption theory, innovation diffusion theory, and cultural identity perspectives into a unified empirical framework, this study extends existing research and provides empirical evidence from the context of college students in Guangxi, China. The findings illustrate that digital cultural consumption is not governed

by a single mechanism but emerges from the interplay between technological usability, experiential enjoyment, innovation attributes, and culturally grounded motivation. Overall, the results highlight the importance of combining digital empowerment with cultural value integration to promote sustainable development of the cultural and creative industry in the digital economy.

Recommendations

1) For Cultural and Creative Enterprises

First, optimize platform usability by streamlining payment processes and ensuring mobile compatibility, as perceived ease of use and facilitating conditions significantly influence purchase intention. Provide clear customer support channels to address potential usage barriers.

Second, integrate interactive features such as AR/VR product previews and 3D displays to enhance hedonic motivation, while designing products with "social sharing" in mind to amplify observability through user-generated content on platforms like "Xiaohongshu" and "Douyin".

Third, authentically incorporate ethnic elements (e.g., Zhuang brocade patterns) with modern aesthetics to strengthen perceived compatibility, ensuring products resonate with young consumers' lifestyles and cultural values.

2) For Universities and Educational Institutions

Integrate local ethnic culture into curricula through elective courses and cultural festivals to enhance students' cultural knowledge, a significant predictor of purchase intention. Establish campus-based digital platforms where students can share cultural experiences and product recommendations to strengthen social connections related to cultural consumption.

Ensure reliable digital infrastructure on campus, including high-speed Wi-Fi and device access, to support students' seamless engagement with digital cultural platforms, addressing the facilitating conditions factor.

3) For Policymakers and Government Agencies

Invest in digital infrastructure development in ethnic minority regions like Guangxi and provide tax incentives for enterprises developing innovative digital tools

(e.g., AR/VR cultural experiences). Launch "culture + digital" initiatives—such as virtual cultural exhibitions and government-supported e-commerce campaigns—to promote Guangxi's ethnic heritage while engaging youth, addressing both cultural identity and technological accessibility.

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Factors Influencing Shared E-Bike Usage Intention among College Students in Chongqing: UTAUT-TAM Integration

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Abstract

This study focuses on students from 5 universities in Dazu District, Chongqing, aiming to explore their willingness to use shared electric bicycles and the influencing factors. It integrates the Diffusion of Innovations Theory, Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), and Theory of Planned Behavior as the analytical framework. An online questionnaire was used for data collection, and 391 valid samples were selected from students who have used shared electric bicycles.

The research results show that there are differences in the acceptance factors of shared electric bicycles among students across different theoretical dimensions: in the diffusion of innovations dimension, the key acceptance factors are compatibility and trialability; in the technology acceptance and utilization dimension, performance expectancy and effort expectancy play prominent roles; in the planned behavior dimension, perceived behavioral control is the core influencing factor. Multiple regression analysis results indicate that the most significant factor affecting students' willingness to use shared electric bicycles is perceived behavioral control (regression coefficient = 0.254), followed by performance expectancy (0.188), compatibility (0.165), trialability (0.124), and effort expectancy (0.113).

The conclusions of this study can provide empirical references for operators of shared electric bicycles to optimize their service strategies in university areas, and also

fill the research gap in the interdisciplinary field of "mountainous terrain, college student groups, and willingness to use shared electric bicycles".

Keywords: Shared electric bicycles; Diffusion of Innovations Theory; Theory of Planned Behavior

Background and Statement of the problem

With the continuous development of industry, greenhouse gas emissions have increased significantly, leading to a rapid rise in global temperatures. As of 2024, research by the World Meteorological Organization (WMO) shows that the global average near-surface temperature is 1.55 ± 0.13°C higher than the average level from 1850 to 1900 (State of the Global Climate, 2024). "Carbon neutrality" and "carbon peaking" have become a global consensus. As of 2024, 148 countries worldwide have explicitly put forward carbon neutrality commitments, and China has committed to achieving carbon neutrality by 2060 (Annual Progress Report on Global Carbon Neutrality, 2024).

Green transportation is a core area for carbon reduction. Shared bicycles and electric bicycles, as green and low-carbon travel modes, help reduce carbon emissions and pollutant emissions from urban travel. By the end of 2024, the deployment volume of shared electric bikes in China had reached approximately 7.13 million units, covering 31 provinces, autonomous regions, and municipalities directly under the Central Government, becoming one of the main choices for people's daily commuting (Research Report on China's Shared Electric Bike Industry (2024-2025), 2025).

Chongqing, as a central city in central and western China, has significant topographic relief. The coverage rate of non-motorized lanes in the main urban area is less than 30% (Scientific and Technological Management of Land and Resources, 2024). However, the emergence of shared electric bikes has made cycling feasible in this mountainous city. Chongqing is home to 68 regular institutions of higher education, with a total enrollment of 1.2 million students in higher education, including 1.005 million undergraduates and junior college students. Nearly 90% of college students have a monthly living expense of 1,000-3,000 yuan, and their daily travel distance is mostly 1-5

kilometers, which is highly consistent with the core applicable distance of shared electric bicycles (MITHILA HASAN, 2023).

Dazu District, as a secondary city in Chongqing, has a high concentration of students and incomplete transportation infrastructure. The number of college students in the district exceeds 32,000 (People's Government of Dazu District, 2024), and its terrain features both mountainous and low-hill characteristics, making it typically representative of Chongqing's overall terrain. Currently, shared electric bike brands such as Hellobike and Meituan have been deployed around colleges and universities in Dazu District.

Despite numerous studies on shared bikes and green transport, there is a lack of research examining the relationship between mountainous terrain and college students' acceptance of e-bikes. This study aims to fill this gap by identifying key factors related to technology adoption and exploring the travel decision-making logic of young people under topographic constraints.

Objective

1. To examine the levels of shared e-bike adoption, user acceptance, perceptions, and user behavior in relation to college students' intention to use shared electric bicycles.
2. To analyze the effects of shared e-bike adoption, user acceptance, perceptions, and user behavior on college students' intention to use shared electric bicycles.

Expected benefits

Government Sector: Provide a specific basis for urban transportation planning institutions to allocate facilities, contribute to the development of a green transportation system, reduce the use of fuel-powered motor vehicles, and promote low-carbon travel among citizens.

Enterprise Sector: Help shared electric bicycle enterprises understand the factors influencing Chongqing college students' willingness to use shared electric bicycles, identify key constraining factors for promotion in university areas, and drive enterprises to produce products more suitable for Chongqing's terrain characteristics and college students' consumption preferences, thereby enhancing product market adaptability.

Researcher Sector: Provide reference for scholars conducting further research on the factors influencing college students' willingness to use shared electric bicycles, saving research time and costs.

Conceptual Framework

This study constructs a conceptual framework integrating four theories to explore the influencing factors of college students' willingness to use shared electric bicycles in mountainous areas. The independent variables include three categories: diffusion of innovation factors (Relative Advantage, Compatibility, Complexity, Trialability), technology acceptance and utilization factors (Perceived Usefulness, Perceived Ease of Use, Social Influence, Effort Expectancy, Performance Expectancy), and planned behavior factors (Attitude Toward Behavior, Subjective Norm, Perceived Behavioral Control). The dependent variable is the willingness to use shared electric bicycles.The theoretical basis of the framework is as follows:Diffusion of Innovations Theory: Explains the diffusion mechanism of shared electric bicycles as an innovative travel tool through innovation attributes such as compatibility and trialability (Rogers, 1962).

Technology Acceptance Model (TAM): Focuses on Perceived Usefulness and Perceived Ease of Use to reflect users' acceptance of shared electric bicycles (Davis, 1989).

Unified Theory of Acceptance and Use of Technology (UTAUT): Supplements Performance Expectancy, Effort Expectancy, and Social Influence to enrich the research perspective of technology acceptance dimensions (Venkatesh et al., 2003). Theory of Planned Behavior (TPB): Analyzes the impact of Attitude Toward Behavior, Subjective Norm, and Perceived Behavioral Control on usage willingness from the perspective of behavioral decision-making (Ajzen, 1985).

Based on the above framework, the following hypotheses are proposed:

H1: Relative Advantage has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H2: Compatibility has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H3: Complexity has a negative impact on college students' willingness to use shared electric bicycles in Chongqing.

H4: Trialability has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H5: Perceived Usefulness has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H6: Perceived Ease of Use has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H7: Social Influence has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H8: Effort Expectancy has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H9: Performance Expectancy has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H10: Attitude Toward Behavior has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H11: Subjective Norm has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

H12: Perceived Behavioral Control has a positive impact on college students' willingness to use shared electric bicycles in Chongqing.

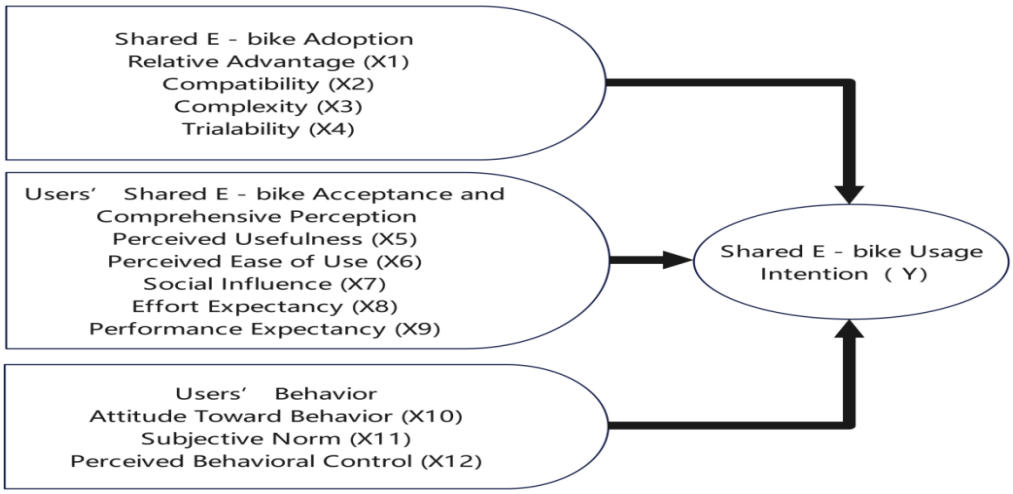


Figure 1 Conceptual Framework of the Study

Note: The framework integrates core dimensions of the Diffusion of Innovations Theory, TAM, UTAUT, and TPB to establish the relationship path between independent variables and the dependent variable.

Research Methodology

Population and Sample

Population: College students who use shared electric bikes at 5 higher education institutions in Dazu District, Chongqing (Chongqing University of Engineering, Chongqing Vocational College of Resources and Environmental Protection, Chongqing Vocational College of Science and Technology, Chongqing Vocational College of Health, Chongqing Vocational College of Telecommunications).

Sampling Method: The W.G. Cochran formula was used to determine the sample size. With a 95% confidence level and a significance level of 0.5, the calculated sample size was 380.44. To guard against invalid questionnaires, 400 surveys were distributed using Probability Proportional to Size Sampling (PPS).

Sample Size: A total of 391 valid samples were obtained after screening invalid questionnaires. Data Collection: The data collection was conducted from October 1 to October 30, 2025, using a mixed distribution method combining online (via the Wenjuanxing platform) and offline (distributed by designated contacts at each university) approaches. Data quality control measures were implemented, including preventing duplicate responses, random sampling, and verifying the completeness of questionnaires.

Data Analysis Methods:

Descriptive Statistics: Demographic characteristics of respondents were analyzed through frequency and percentage; the distribution characteristics of each research variable were calculated using mean, standard deviation, skewness, and kurtosis to determine whether the data distribution conformed to normality (values of skewness and kurtosis between -3 and 3 were considered approximately normally distributed).

Multiple Regression Analysis (MRA): A multiple regression model was constructed with willingness to use as the dependent variable and 12 dimensions of independent variables to explore the intensity and direction of the impact of each factor on behavioral intention. Hypothesis testing for regression analysis premises was performed, including tests for error normality, homoscedasticity, autocorrelation, and multicollinearity.

Research Results

Table 1 Demographic Characteristics of Sample Users (N=391)

Characteristic	Category	Frequency	Percentage (%)
Gender	1）Male	321	82.1
	2）Female	70	17.9
University	1）Chongqing University of Technology and Engineering	58	15.3
	2）Chongqing Vocational College of Resources and Environmental Protection	105	27.9
	3）Chongqing Vocational College of Science and Technology	126	33.2
	4）Chongqing Vocational College of Health	57	15.3
	5）Chongqing Vocational College of Telecommunications	30	8.2
Grade	1）Freshman	145	38.6
	2)Sophomore	101	26.6
	3)Junior	86	22.5
	4)Senior	44	12.3
Monthly living expenses	1）1000 yuan and below	84	23.3
	2）1000-1500 yuan	162	42.7
	3）1501-2000 yuan	70	17.9
	4）2001-3000 yuan	25	6.4
	5）Above 3000 yuan	35	9.7

The analysis of the four dimensions of diffusion of innovation factors showed that the respondents had the highest recognition of "Relative Advantage" (Mean = 4.01), followed by "Compatibility" (3.95), "Complexity" (3.88), and "Trialability" (3.61). All skewness and kurtosis indices were between -3 and 3, showing an approximately normal distribution. The overall mean value was 3.86, indicating that college students had an overall highly

positive perception of the core innovation diffusion characteristics of shared electric bicycles.

Table 2 Mean, S.D., Skewness, and Kurtosis of Diffusion Innovation Factors

Diffusion Innovation Factors	Evaluation				
	Mean(μ)	Standard Deviation(σ)	Skewness	Kurtosis	Level Definition
1.Relative Advantage	4.01	0.70	-0.29	-0.74	High
2.Compatibility	3.95	0.79	-0.23	-0.93	High
3.Complexity	3.88	0.79	-0.43	-0.12	High
4.Trialability	3.61	0.86	-0.22	-0.17	High
Total	3.86	0.79	-0.30	-0.49	High

The analysis of the five dimensions of technology acceptance and utilization factors showed that "Perceived Usefulness" had the highest mean value (3.93), followed by "Performance Expectancy" (3.87), "Social Influence" (3.51), "Effort Expectancy" (3.21), and "Perceived Ease of Use" (2.89). The overall mean value was 3.48, indicating a positive impact on college students' willingness to use.

Table 3 Mean, S.D., Skewness, and Kurtosis of Technology Acceptance and Utilization Factors

Technology Acceptance and Utilization Factors	Evaluation				
	μ	σ	Skewness	Kurtosis	Level Definition
1.Perceived Usefulness	3.93	0.81	-0.49	0.19	High
2.Perceived Ease of Use	2.89	0.60	0.13	-0.39	Medium
3.Social Influence	3.51	0.45	-0.17	1.22	High
4.Effort Expectancy	3.21	0.59	-0.64	0.86	Medium
5.Performance Expectancy	3.87	0.81	-0.32	-0.28	High
Total	3.48	0.65	-0.28	0.30	High

The analysis of the three dimensions of planned behavior factors showed that "Attitude Toward Behavior" had a mean value of 3.84, "Perceived Behavioral Control" 3.80, and "Subjective Norm" 2.83. The overall mean value was 3.49, indicating a positive impact on college students' willingness to use.

Table 4 Mean, S.D., Skewness, and Kurtosis of Planned Behavior Factors

Planned Behavior Factors	Evaluation				
	μ	σ	Skewness	Kurtosis	Level Definition
1.Attitude Toward Behavior	3.84	0.78	-0.31	-0.30	High
2.Subjective Norm	2.83	0.62	-0.63	0.40	Medium
3.Perceived Behavioral Control	3.80	0.80	-0.13	-0.97	High
Total	3.49	0.73	-0.36	-0.29	High

Table 5 Summary of Research Results

Model	R	R^2	Durbin-Watson	Std. Errorof the estimate
1	.836	.698	2.00	0.462

Table 6 ANOVA result of the research

Model	Sum of Squares	df	Mean Square	F	sig
Regression	186.826	12	15.569	72.928	.000
Residual	80.696	378	0.213		
Total	267.522	390			

Table 7 Regression Coefficients and Significance Analysis

Independent Variables	Unstandardized CoefficientsBeta	S.E.B	Standardized Coefficients Beta	t	P-value ($Sig.$)
	B	SE_b	βi		
Constant	-0.71	0.245		-2.899	0.004
Relative Advantage(X1)	0.028	0.054	0.024	0.526	0.6
Compatibility(X2)	0.173	0.054	0.165	3.207	0.001*
Complexity(X3)	-0.001	0.056	-0.001	-0.023	0.982
Trialability(X4)	0.119	0.045	0.124	2.674	0.008*
Perceived Usefulness (X5)	0.081	0.061	0.079	1.326	0.186
Perceived Ease of Use (X6)	0.074	0.042	0.054	1.775	0.077
Social Expectation(X7)	0.028	0.053	0.015	0.53	0.596
Effort Expectancy(X8)	0.158	0.046	0.113	3.445	0.001*
Performance Expectancy(X9)	0.192	0.056	0.188	3.416	0.001*
Attitude Toward Behavior (X10)	0.035	0.059	0.033	0.594	0.553
Subjective Norm (X11)	0.057	0.04	0.042	1.414	0.158
Perceived Behavioral Control (X12)	0.264	0.05	0.254	5.26	0.000*

Notice: *is statistically significant at 0.05 level, $p<0.05$

The five key dimensions (Compatibility, Trialability, Effort Expectancy, Performance Expectancy, and Perceived Behavioral Control) were significantly positively correlated with the willingness to use shared electric bicycles ($p < 0.05$), while the other seven dimensions showed no statistically significant correlation with the usage willingness.

The adjusted R^2 value was 0.698, indicating that the independent variables could explain approximately 69.8% of the variation in the dependent variable. The Durbin-Watson value was 2.00, meeting the conditions for multiple regression analysis. The F-test result was significant ($p = 0.000$), indicating that the regression model was valid.

Regression Coefficients and Significance Analysis: Compatibility (X2), Trialability (X4), Effort Expectancy (X8), Performance Expectancy (X9), and Perceived Behavioral Control (X12) had statistically significant effects on shared e-bike usage intention ($p < 0.05$).

The regression equation was:

$$Y = -0.710 + 0.165X_{2} + 0.124X_{4} + 0.113X_{8} + 0.188X_{9} + 0.254X_{12}.$$

The hypothesis testing results showed that H2, H4, H8, H9, and H12 were supported, while the other hypotheses were not supported.

Summary of the Study

This study explored the influencing factors of college students' willingness to use shared electric bicycles in Dazu District, Chongqing, by integrating four theoretical frameworks. The empirical results showed that planned behavior factors, UTAUT core dimensions, and innovation diffusion characteristics jointly exerted a significant positive impact on usage intention. Perceived behavioral control was the most influential factor, followed by performance expectancy, compatibility, trialability, and effort expectancy.

The four theoretical frameworks formed a complementary explanatory system: the Diffusion of Innovations Theory explained the diffusion mechanism through compatibility and trialability; the integrated TAM-UTAUT framework revealed the core logic of technology acceptance through performance expectancy and effort expectancy; the Theory of Planned Behavior clarified the basis of behavioral decision-making through perceived behavioral control.

The research conclusions can provide empirical references for shared electric bicycle operators to optimize their service strategies in university areas. Future research

can further expand the research scope, enrich research variables, innovate research methods, and extend research objects to improve related field studies.

Discussions

User Analysis Under the Diffusion of Innovations Theory

Compatibility and trialability emerged as significant predictive variables, which aligns with both Rogers' (1962) Diffusion of Innovations Theory and recent empirical findings in shared mobility research. Bokolo (2023) confirmed that compatibility with daily scenarios is a key driver of shared e-mobility adoption in smart communities, which echoes our result that "technology-user habit fit" and "product-scenario demand fit" jointly promote diffusion among college students. Regarding trialability, our finding that low-cost trials are critical for cost-sensitive student groups (23.3% with monthly living expenses ≤1,000 yuan) is consistent with Zhu et al. (2025), who found that free experiences and student discounts effectively reduce adoption barriers for young users. However, unlike Ibrahim et al. (2022), who reported that observability (a core dimension of DOI) significantly impacts university students' bicycle use intention, observability was not included in our final model—this discrepancy may stem from the mountainous terrain context, where practical performance (e.g., uphill power) is more salient than social visibility of usage. Additionally, relative advantage (Mean=4.01) and complexity did not reach statistical significance, which may be because shared e-bikes have become a mature travel tool in campus scenarios: their "time-saving and labor-saving" advantages are universally recognized (thus no longer a differentiated factor), and the operation process (e.g., APP unlocking, payment) has been simplified to a basic standard, making complexity irrelevant to usage decisions.

User Analysis Under the Integrated TAM-UTAUT Framework

Performance expectancy and effort expectancy were identified as key driving factors, which is consistent with the UTAUT framework (Venkatesh et al., 2003) and empirical evidence from shared transportation research. Khan et al. (2025) found that performance expectancy (e.g., punctuality, comfort) is the most influential UTAUT dimension for university students' shared e-bike use intention, which supports our result that battery life and ergonomic design (core components of performance expectancy)

address mountainous riding pain points. Regarding effort expectancy, our finding that it includes both operational and service effort (e.g., after-sales efficiency, guide clarity) extends Venkatesh & Davis' (2000) original construct and aligns with Duan et al. (2023), who reported that service-related costs (e.g., complaint response speed) significantly impact shared mobility user retention.

Notably, two UTAUT/TAM dimensions—Social Influence and Perceived Ease of Use—were non-significant. For social influence (Mean=3.51), the non-significance may be attributed to the autonomous decision-making characteristics of college students: as young adults, they have formed independent travel preferences and are less likely to be influenced by peers, family, or social norms when choosing travel tools (Xia, 2022). In mountainous travel scenarios, where functional needs (e.g., uphill capability) are critical, social approval or group behavior has a negligible impact compared to practical value. For perceived ease of use (Mean=2.89), unlike Zhu et al. (2025)'s finding in plain cities, it did not enter the final model—this highlights the terrain constraint effect: students are willing to tolerate minor operational inconveniences (e.g., APP positioning deviations) to meet their core need for labor-saving uphill travel, making functional performance more important than operational simplicity.

User Analysis Under the Theory of Planned Behavior

Perceived behavioral control (PBC) emerged as the most influential factor (β=0.254), which aligns with Ajzen's (2020) TPB proposition and empirical findings in constrained travel contexts. Ji et al. (2021) found that PBC (e.g., vehicle availability, operational feasibility) is the core predictor of shared bike use intention in mountainous cities like Lanzhou, which supports our result that resource accessibility and uphill riding adaptability shape students' control perceptions.

However, Subjective Norm (Mean=2.83) was non-significant, which differs from Chen et al. (2022)'s report of moderate social influence in plain areas. This discrepancy, combined with the non-significance of social influence (UTAUT), further confirms that college students' travel decisions in mountainous contexts are dominated by pragmatic considerations rather than social approval. As Xia (2022) noted, Chinese college students exhibit "pragmatic decision-making" when facing functional demands: in mountainous travel, where efficiency and physical effort are key concerns, they prioritize practical

value (e.g., cost, uphill performance) over the opinions of others. Additionally, attitude toward behavior (Mean=3.84) was non-significant due to high consistency—over 90% of students held positive attitudes toward shared e-bikes, which is common in mature innovation adoption scenarios (Rogers, 1962) where core user needs are fully met.

Recommendations

Optimize Perceived Behavioral Control Based on TPB: Guided by the core proposition of the Theory of Planned Behavior (Ajzen, 2020) that "behavioral controllability determines intention", operators should optimize resource allocation and cost control to enhance students' sense of control. For example, adopt demand-driven vehicle deployment strategies based on travel peak data (e.g., off-campus shopping and class hours) to ensure resource accessibility; design price mechanisms compatible with the consumption capacity of young groups (42.7% with monthly living expenses of 1,000-1,500 yuan), such as academic-period pricing packages or freshman adaptation subsidies.

Enhance Performance Expectancy in Mountainous Scenarios: In line with the UTAUT theory's emphasis on "performance outcomes as core drivers" (Venkatesh et al., 2003), product design should prioritize terrain adaptability. Key improvements include optimizing battery life to address uphill power shortage risks, enhancing riding comfort through ergonomic design, and improving information transparency (e.g., real-time power display) to reduce uncertainty in mountainous travel.

Strengthen Compatibility: Increase vehicle deployment during peak hours such as morning and evening classes and weekends; optimize the APP unlocking process to support one-click login; cooperate with business districts and public transport companies to set up exclusive parking spots to improve the connection efficiency of the "last kilometer".

Facilitate Trialability Based on Diffusion of Innovations Theory: Following Rogers' (1962) view that "low-risk trials accelerate innovation diffusion", operators should reduce adoption barriers for cost-sensitive student groups (23.3% with monthly living expenses ≤1,000 yuan). Feasible approaches include implementing risk-free trial mechanisms (e.g., no-cost initial rides, fault-free refunds) and exclusive preferential policies linked to

student identity authentication, which align with the "low-cost access" characteristic of trialability in youth groups.

Reduce Effort Expectancy Through Service Optimization: Extending the UTAUT framework's connotation of effort expectancy (Venkatesh & Davis, 2000), which includes both operational and service effort, operators should improve service efficiency and user guidance. This involves building a multi-channel after-sales response system with clear time limits, and developing scenario-specific user guides (e.g., video tutorials for mountain riding) to reduce cognitive and operational costs.

Application Recommendations of the Research Results

Universities can cooperate with operators to set up exclusive parking areas and charging stations for shared electric bicycles on campus, standardize vehicle parking order, and incorporate riding safety education into freshmen orientation. Management departments can promote operators to establish campus service standards, clarify requirements such as after-sales response time and vehicle maintenance cycles, and coordinate the coordinated development of shared electric bicycles with campus transportation and urban short-distance transportation to improve the green travel system.

Future Research Directions

Deepen Gender-Specific Analysis: Conduct comparative research on male and female students' travel behavior and demand characteristics, focusing on differences in safety requirements, price sensitivity, and usage scenarios, to provide targeted optimization suggestions for operators and management departments.

Expand Research Scope and Sample Representativeness: Extend samples to universities in different terrains (plains, hills, mountains) and city tiers (first-tier cities, districts, and counties) across Chongqing and even the whole country, incorporate more female samples (currently only 17.9%), and verify the generalizability of research conclusions.

Enrich Research Variables: Introduce variables not included such as "vehicle safety", "brand trust", "competitor substitution effect" (e.g., shared scooters and ride-hailing services), and "campus policy support" to construct a more comprehensive influencing factor model.

Innovate Research Methods and Data Sources: Add qualitative methods such as in-depth interviews and focus groups on the basis of quantitative research to explore students' deep-seated needs and pain points regarding product design and service quality; conduct a 6-12 month longitudinal tracking study on the same group of users to analyze the dynamic changes of usage willingness with usage frequency and experience feedback; combine APP backend data (riding routes, usage duration, fault feedback) with questionnaire data to reduce subjective bias and improve research accuracy.

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Structural Drivers of Wage Inequality: An Analysis of Minimum Wage Policy Impact on Thai and CLM Migrant Workers

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Abstract

The declining working-age population of Thailand's labor force relies on both Thai and large numbers of migrant workers from Cambodia, Laos, and Myanmar (CLM), who are disproportionately absorbed into both the formal and informal sectors, specifically into low-wage, unstable jobs with weak enforcement and vulnerable employment conditions. The study aims to examine the impact of changes to the minimum wage policy on the wages of Thai and CLM workers in the formal and informal sectors. The analysis uses minimum wage data and cross-sectional, pooled third-quarter data from the Thailand Labor Force Survey (2023-2024). It focuses on private-sector employees, who represent most Thai and CLM workers. This research employs continuous difference-in-differences to identify how changes in the minimum wage policy affect Thai and CLM differently before (2023) and after (2024).

The result indicates that the wage distribution appears to improve wages for both Thai and CLM workers following the policy changes. The continuous difference-in-differences result shows that a 1-percentage-point growth in minimum wage significantly reduces the hourly wage response in the formal sector by approximately 3.16% for CLM workers relative to Thai workers. Otherwise, a 1-percentage-point growth in minimum wage significantly increases the hourly wage response by approximately 1.93% for CLM workers compared to Thai workers in the informal sector. Overall, the findings indicate the existing vulnerability of CLM workers and enforcement gaps that continue to hinder the transmission of wage outcomes across sectors, suggesting expanding the social security fund coverage and strengthening law enforcement and compliance in the Thai labor market.

Keywords: Minimum Wage, Wage Differential, Thai, CLM, continuous Differences in Differences

Background and Statement of the Problem

The migration pattern has rapidly increased in Southeast Asia due to political instability, a lack of job opportunities, and income differences between countries. Migrants from CLM countries move to Thailand due to demographic reasons, better job opportunities, and wage disparities in neighboring countries (Brixi & Evans, 2012). Moreover, the decline in the working-age population may lower productivity and slow economic growth in Thailand, thereby creating more job opportunities for CLM migrant workers. Those dire economic situations have driven many civilians, particularly working-age civilians and young, skilled & unskilled workers from neighboring countries, to move to Thailand. In parallel, women migrants from CLM countries move both internally and across borders to work in Thailand to attempt better living conditions (Sakulsri et al., 2020). In Thailand, migrant workers are concentrated across multiple sectors, particularly in manufacturing, construction, agriculture, seafood and fisheries, and other low-paid, low-skilled Thai industries, which are often described as "Triple-D" (dirty, demanding, and dangerous) (Arnold, 2005).

In Thailand, the first minimum wage policy was introduced in 1972 and later extended by the Ministry of Interior and the National Wage Committee (NWC). The Thai government introduced a new minimum wage policy on the 1st of January 2024, with minimum wages ranging from 330 to 370 baht across 77 provinces.

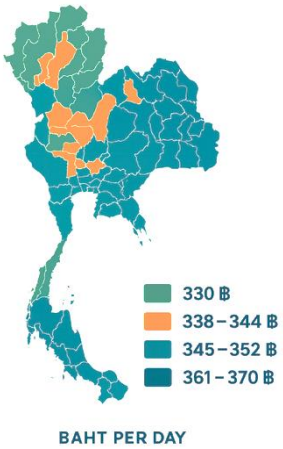


Fig. 1. Distribution of New Minimum Daily Wage Rate across the Province as of 1st January 2024

Note: The figure illustrates the new minimum wage policy across provinces, adapted from the Ministry of Labor 2023, "Notification of the Wage Committee on Minimum Wage Rate (No. 12)".

Figure 1 describes the distribution of the new minimum wage changes across all 77 provinces on 1st January 2024, and the most populated provinces with industrial activity and urban and tourism-oriented provinces found higher minimum wage improvements. The minimum wage plays a critical role by setting a floor on wages for local workers and legal migrants (Epstein et al., 2013). Although CLM migrant workers in Thailand account for 10% of the total labor force and have made a significant contribution to the Thai economy, relatively little is known about the impacts of the minimum wage on migrant workers (Bhula et al., 2019). CLM workers are systematically treated differently from native Thai workers despite equivalent skills and qualifications in both the formal and informal sectors, a reality rooted in a complex interplay of economic, legal, and socio-cultural factors that constitute pervasive discrimination. Being assigned to 3D jobs increases the likelihood of being assigned to low-wage jobs, informal employment, and heavy, high-risk work, including long hours and a lack of security (Quadrini, 2018).

The Thai government has sought to extend social protection nationwide, including to informal workers, under Article 40 of the Social Security Act. In Thailand, the formal sector comprises workers with access to the Social Security Fund (SSF), while the informal sector comprises workers without such access to the Social Security Fund (SSF). A person of at least 15 years of age whose employment lacks protection or is regulated by the social security system, as per the National Statistical Office. Nevertheless, the enrolment of the Social Security Fund (SSF) remains far below the size of the informal workforce due to low and unstable incomes, cost, limited awareness & benefits, and administrative barriers, resulting in coverage gaps in the registration process. Since the minimum wage policy doesn't apply to government and agricultural workers, other private-sector employers covered by the policy would be accountable for both formal workers under the Social Security System and informal workers without protection by specific laws and unstable employment, where the majority of CLM workers are concentrated.

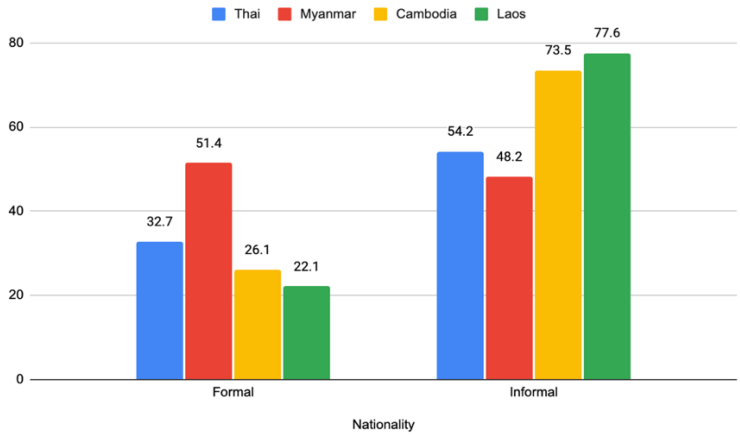


Fig 2. Percentage distribution of workers in the formal and informal sectors.
Note: From the Thai labor force surveys 2023 & 2024 by the National Statistical Office of Thailand, Bangkok

Figure 2 presents the shares of workers under the Social Security Fund (SSF) as formal-sector employment and workers not under SSF accessibility as informal-sector employment, as a proportion of the Thai labor force, as surveyed in 2023 and 2024. In the labor force, there is a clear and persistent pattern: workers from Cambodia, Laos, and Thailand are mostly in the informal sector, not registered with the SSF (about two-thirds), compared to the formal sector, registered with the SSF (about one-third). In contrast, Myanmar workers appear to have a similar distribution across formal and informal employment. Within this dual structure, CLM workers are disproportionately clustered in low-wage, informal, and risky occupations, frequently earning below the minimum wage and in violation of Thai labor market law and policy. Studies on minimum wage hikes across global studies can be seen as beneficial to native workers compared to migrant workers, who are often in irregular, uncovered, and informal work. National Minimum Wage Hike in the UK suggested that migrant workers have a chance to increase their wages in sectors where irregular conditions, compliance, and social coverage are weaker (Dustmann et al., 2013). The sector without social protection or law enforcement led employers to shift workers, particularly migrant workers, to low-wage, less protected jobs, which is significant for male workers with low skills and undocumented status (Ingwersen and Thomsen, 2023). Otherwise, the minimum wage jump can enhance reallocation to informal or less regulated jobs, and wage gaps between native and

migrant workers were narrow at the lower end of the wage distribution at first (Biewen et al., 2022). The policy impact is more unfavorable for low-wage workers to earn wage increases, but this effect is more significant in large industries and sectors where the region has strong enforcement.

Many studies have already shown that informal workers in Thailand are more likely to earn lower wages and face higher occupational risks, suggesting that informality is often a constraint rather than a voluntary choice. Wage gaps between formal and informal employment are observed across all wage quartiles (Korwatanasakul, 2021). The documented migrants and native workers with access to social security funds and law enforcement can be affected positively by the minimum wage policy, rather than undocumented and informal migrant workers who don't have access to SSF with the weaker law enforcement (Leckcivilize, 2015; Carpio et al., 2018; Lathapipat and Poggi, 2016). Leckcivilize (2015) highlights that minimum wages can reduce wage gaps among workers in the formal sector, but they don't in the informal sector due to high noncompliance and weak law enforcement. Carpio et al. (2018) used the Thai Labor Force Survey (LFS) and Household Socioeconomic Survey during the period between 2001 and 2011 to analyze the 2012 minimum wage impact on the labor market and welfare, and they found that the minimum wage hike has a significant increase in wages for low-wage workers, particularly for the young, less educated and elderly. Furthermore, the study by Lathapipat and Poggi (2016) revealed that the minimum wage policy is significant for average workers, particularly for the younger age group between 15 and 24 years old, whereas it has no effect on workers at the bottom of the distribution. Evidence from numerous Thai studies shows that informal workers experience substantial wage penalties relative to formal workers across the entire wage distribution, with the largest gaps at the bottom, and that informal employment is associated with higher occupational risks and more precarious livelihoods. Although the existing literature examines either formal or informal wage gaps in aggregate or migrant-native differentials, it does not systematically analyze how nationality and formality jointly shape wage outcomes. Informal employment accounts for a large share of the labor market in Thailand but may adversely affect law enforcement, social security, economic growth, and social well-being.

Despite national laws and regulations that equally apply to all workers regardless of their demographic and nationality, migrant workers continue to encounter structural obstacles due to the discriminatory regulations, lack of legal protections, and limitations on registering SSF funds. The existing studies and literature primarily highlight the existing gaps in how minimum wage policy changes affect different segments of the labor market in Thailand across sectors, firm size, demographic characteristics, human capital factors, gender, and workers. A critical empirical gap persists and remains questioned in the Thai context: how the minimum wage policy differently impacted CLM workers versus Thai workers in formal and informal employment. There is still limited causal evidence on whether CLM migrant workers experience policy impacts differently across the formal and informal sectors, and how these minimum-wage policy reforms interact with this segmentation. To address these limitations, this study aims to explore the intersections and quantify the heterogeneous causal effects of policy changes using Thai labor force survey data. By focusing on Thai and CLM workers, this study aims to quantify how nationality and informality intersect to shape earnings in Thailand's labor market.

Research Objective

1. To analyze whether minimum wage growth affects the wages of Thai and CLM workers differently.
2. To investigate these differences related to the distinction between the formal and informal sectors.

Expected Benefits

1. To provide additional evidence on the existing heterogeneous causal effects between Thai and CLM migrant workers across formal and informal sectors.
2. To identify sectors where the impact of policy doesn't transmit equally and to provide improvements for better social security plan registration, law enforcement, and Social Security Fund (SSF) coverage, particularly for migrants and low-wage workers.
3. To suggest analytical approaches for monitoring policy change compliance at the provincial and industry levels to strengthen Thailand's labour market regulation.

Conceptual Framework

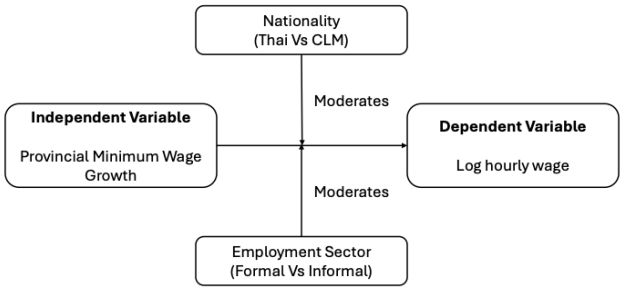


Fig 3. Conceptual Framework

The researcher develops a conceptual framework to analyse the relationship between provincial minimum wage growth and the real hourly wage outcomes for Thai vs CLM workers in the private sector of the Thai Labor Force. The study focuses on formal and informal sector employment as moderating factors, where the policy's impact may not be transmitted equally across these sectors due to weaknesses in law enforcement and limitations in registering with the Social Security Fund (SSF). This may cause heterogeneous wage differentials between Thai and CLM workers. In addition, other control variables include demographic variables such as age, gender, education attainment, industry, firm size, married, urban or rural, and regional fixed effects to account for determinants of wage outcomes. This is illustrated in Figure 3.

The study hypotheses are as follows

1. The 2024 provincial minimum wage policy increases workers' real hourly wages in Thailand.

2. The effects of provincial minimum wage growth on real hourly wages differ between Thai and CLM migrant workers in the formal employment sector.

3. The effects of provincial minimum wage growth on real hourly wages differ between Thai and CLM migrant workers in the informal employment sector.

Research Methodology

Defining the Continuous Treatment Variable

In Thailand, all provinces have experienced increases in the minimum wage, with slight differences in magnitude. The analytical approach of this study is a continuous difference-in-differences model, with the continuous treatment variable defined as the proportional change in the provincial minimum wage before and after the policy change. In line with labor market segmentation theory, employment is divided into formal and informal sectors based on SSF registration, allowing us to examine how the policy's effects differ in wages for Thai and CLM workers across these sectors. The continuous difference-in-differences framework reports heterogeneous time trends across worker groups, demonstrating the limitations of models that rely on additive time effects. Although the pre-policy period in this study is 2023, we create a treatment variable using the minimum wage data from the Ministry of Labor and the National Wage Committee's Notification on Minimum Wage Rate for 2022 and 2024, since no minimum wage was introduced in 2023. Therefore, the 2022 minimum wage represents the last minimum wage change effect before the 2024 reform. This treatment variable measures the provincial growth rate of the statutory minimum wage between 2022 (pre-policy minimum wage change) and 2024 (post-policy minimum wage change). This approach adapts the empirical strategies used in previous studies on minimum wage policy (Cengiz et al.,2019; Blau et al., 2023; Bailey et al., 2021). This treatment variable examines the extent to which workers in different provinces are exposed to the policy change and leverages cross-provincial variation in policy intensity. The continuous treatment variable is defined as

$$MWgrowth_p = \frac{MW2024_p - MW2022_p}{MW2022_p}$$

where MWgrowthp captures the proportional growth of the minimum wage in province p, MW2024p represents the statutory minimum wage in province p in 2024 (post policy), and MW2022p represents the statutory minimum wage in province p in 2022 (pre policy).

Estimating Wage Determinants and Policy Effects within the Mincer Earnings and Continuous differences in differences framework

The study applies continuous difference-in-differences methodology, the standard approach in labor economics for policy evaluation (Autor, Manning & Smith, 2016). To examine whether the policy's average impact is heterogeneous and sensitive to pre-existing structural segmentation in Thailand's labor market. These specifications are rooted in the canonical earnings function, ensuring comprehensive control for human determinants of wages and the dependent variable, taking the natural logarithm of hourly wage, following the Mincerian framework, which captures percentage returns to human capital investments (Mincer, 1974; Deming, 2024). To analyze the wage determinants of the policy effects, this study grounded the Mincerian tradition but advanced in two critical respects. First, the use of education attainment dummies to allow for non-linearity, reflecting the quality of educational achievement, unlike the classical earnings equation, which used continuous years of schooling as the measure of education. Second, age serves as a proxy for labor-market experience, with age2 capturing the empirically observed inverted U-shaped lifecycle earnings profile: rapid wage growth early in the career, peaking in midlife, and flattening or falling thereafter (Polacheck, 2004). Accordingly, the comprehensive specification is a continuous-differences-in-differences model.

$$\log(Wage)_{ipt} = \beta_0 + \beta_1 MWgrowth_p + \beta_2 post_t + \beta_3 CLM_i + \beta_4(MWgrowth_p \times post_t) + \beta_5(MWgrowth_p \times CLM_i) + \beta_6(post_t \times CLM_i) + \beta_7(MWgrowth_p \times post_t \times CLM_i) + \beta_k X'_i + \gamma_r + \varepsilon_{ipt}$$

where log $(Wage)_{ipt}$ represents the dependent variable, the natural logarithm of the worker's real hourly wage, where all monthly wage, daily wage, and weekly wage are converted into hourly wage, consistent with the Mincer framework's focus on percentage-based returns. Using the log, the estimated coefficients can be interpreted as approximate percentage changes in wages (Wooldridge, 2019). After the regression, the interaction term ($MWgrowth_p$ x $post_t$ x CLM_i) is calculated as a percentage effect: $(e^{\beta x 0.01} - 1) \times 100$ to show a 1 percentage point increase in provincial minimum wage growth. $MWgrowth_p$ is the continuous treatment variable capturing the proportional change in statutory minimum wage in $provinces_p$ between 2022 to 2024, $Post_t$ is a dummy variable for time fixed effect 1 for the year 2024 (post-policy) and 0 for the year 2023 (pre-policy), CLM_i is

a dummy variable whether worker is a (Cambodia, Laos and Myanmar) with Thai workers as the reference group.

X'_i represents the vector of control variables. Control variables include the dummy variable for workers living in the urban area or not , marital status (single or married), head of household or not, demographic variables including age and age^2, dummy variable for gender (male or female), and, moreover, employment characteristics like part-time or full-time worker, employment status (formal or informal) where workers register Social Security Fund(SSF) is denoted as formal and workers who don't register SSF is denoted as informal, firm size(small firm with lower than 49 employee or large firm with over 50 employee), industry group using the (production or services) where International Standard Industrial Classification of All Economic Activities (ISIC) standard is used to stratify industry group, and γ_r is the region fixed effects, which control for all time-invariant, unobserved characteristics across regions such as different minimum wage levels, economic structures, institutions, and different institutions and ε_{ipt} is the error term. By clustering all standard errors at the region level to account for within-region correlation, the model can ensure it identifies effects by comparing workers within the same region over time.

All specifications are estimated using Ordinary Least Squares (OLS), with region-clustered standard errors providing conservative and reliable inference, ensuring robustness to within-group correlation. Due to limitations in the data structure, the analysis focuses only on the 2023-2024 period, limiting the ability to test parallel trend assumptions. Nevertheless, the empirical strategy exploits cross-provincial variation in minimum wage growth to identify wage responses across Thai Vs CLM workers.

Data used in the study

The study used the Thai Labor Force Survey from the National Statistical Office, which is widely used in labor economics research because it provides a robust empirical foundation for both descriptive and causal analyses, including policy changes, minimum wage impacts, informality, and gender wage inequality. The study focuses on third-quarter data for 2023 and 2024. Distortion from the peak Covid-19 period can be reduced, and the analysis can focus on nationality for countries without a record of

country of origin before 2023, thereby making it more reflective. The benefit of using third-quarter data is that it suggests labor mobility, especially among agricultural workers, is heavily influenced by seasonal factors, thereby reducing potential bias in labor mobility analysis, particularly in contexts where seasonal migration shapes labor force dynamics (Sussangkarn, 1995). The study focuses on working-age individuals aged 15 to 65 in the private sector.

Table 1: Summary Statistics of The Key Variable from the Thai Labor Force Survey (2023-2024)

Variables	2023(Pre)		2024(Post)	
	Thai N = 9,046	CLM N = 1,596	Thai N = 9,319	CLM N = 1,991
Hourly wage (THB)	45 (11)	45 (7)	46 (11)	46 (10)
Age	40 (13)	32 (9)	41 (13)	32 (8)
Firm size				
Large firm	1,930 (21%)	725 (45%)	1,870 (20%)	1,004 (50%)
Small firm	7,116 (79%)	871 (55%)	7,449 (80%)	987 (50%)
Gender				
Male	5,435 (60%)	941 (59%)	5,551 (60%)	1,183 (59%)
Female	3,611 (40%)	655 (41%)	3,768 (40%)	808 (41%)
Married	2,104 (23%)	38 (2.4%)	2,167 (23%)	53 (2.7%)
Employment				
Formal	3,126 (35%)	806 (51%)	3,003 (32%)	1,057 (53%)
Informal	5,920 (65%)	790 (49%)	6,316 (68%)	934 (47%)
Urban Residence	4,871 (54%)	1,143 (72%)	5,131 (55%)	1,311 (66%)
Household head	3,719 (41%)	889 (56%)	3,827 (41%)	1,123 (56%)
Education level				
None	140 (1.5%)	740 (46%)	190 (2.0%)	918 (46%)
Lower Education	8,906 (98%)	856 (54%)	9,129 (98%)	1,073 (54%)
Part-time (<40 hrs/wk)	1,082 (12%)	58 (3.6%)	871 (9.3%)	46 (2.3%)
Industry Type				
Services	3,867 (43%)	557 (35%)	4,106 (44%)	658 (33%)
Production	5,179 (57%)	1,039 (65%)	5,213 (56%)	1,333 (67%)
Region				
Bangkok (Metropolitan)	383 (4.2%)	151 (9.5%)	385 (4.1%)	198 (9.9%)
Central Region	3,782 (42%)	950 (60%)	3,742 (40%)	1,292 (65%)
Northern Region	1,529 (17%)	124 (7.8%)	1,531 (16%)	133 (6.7%)
Northeastern Region	1,586 (18%)	7 (0.4%)	1,870 (20%)	25 (1.3%)
Southern Region	1,766 (20%)	364 (23%)	1,791 (19%)	343 (17%)
Mean (SD); n (%)				

Note: The Author's calculation using the Thai labor force survey (2023-2024) data and the table illustrates the mean (SD) for continuous variables and n (%) for categorical variables. Provinces are omitted.

Table 1 presents the summary statistics for core analytic variables from the Thai Labor Force Survey (2023-2024), disaggregated by policy period (pre-2023 vs post-2024) and nationality (Thai Vs Cambodia, Laos, and Myanmar (CLM)), which enables the identification of clear, policy-relevant patterns in worker characteristics and labor market segmentation. This study included 21952 individuals, of whom 18365 are Thai workers, and 3587 are CLM workers, retrieved from the labor force survey conducted in 2023 and 2024. The mean hourly wage is found to be higher after the policy changes in 2024, with minimum wage interventions responding to wage distribution. Both Thai and CLM workers are more likely to be employed in small firms and in informal employment than in large, formal employment. CLM workers are more likely to be concentrated in the production sector, whereas most Thai workers are concentrated in the service sector. CLM workers are mostly younger, less educated, and less likely to be married or to be heads of household. To ensure a reliable comparison between Thai and CLM workers, the study excluded government sector workers, employers, state enterprise employees, members of cooperatives/associations, own-account workers, and unpaid family workers from the analysis, focusing only on private sector employees. Overall, the minimum wage policy changes are likely to vary across nationality, employment, industry group, and demographic groups, a nuanced feature to account for subsequent analyses.

Despite limitations in the parallel-trends assumptions for wage differentials across nationality due to the absence of workers' country of origin and nationality identifiers in the Thai Labor Force Survey Data prior to 2023, we rely on existing parallel trends to reveal wage distribution patterns. Although the LFS provides survey weights, the study does not use them, as its objectives are to estimate the relationship between changes in minimum wage policy and wage outcomes for Thai and CLM workers. Nevertheless, persistent differences in wage estimates may suggest heterogeneous wage responses among Thai and CLM workers.

Research Results

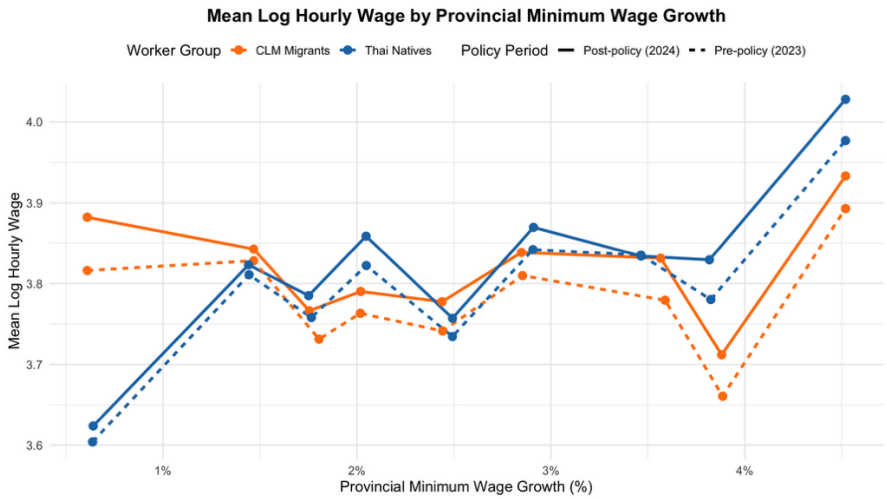


Fig. 4. The pattern of the provincial minimum growth effect on mean log hourly wage.

Note. The line graph shows the preliminary mean log hourly wage growth by provincial minimum wage after the policy changes in 2024, stratified by Thai vs CLM.

Figure 4 represents the relationship between provincial minimum wage growth and the mean log hourly wage for Thai and CLM workers between the pre-policy period (2023) and the post-policy period (2024). The results show that the mean log hourly wage distribution of Thai workers is higher than that of CLM workers. The results indicate that provincial minimum wage growth affected and widened the wage distribution of both CLM and Thai workers, but the magnitude differed. The result provides preliminary descriptive evidence on wage differentials across groups and motivates the subsequent econometric analysis using continuous difference-in-differences. The analysis reports a positive association between provincial minimum wage growth and mean log hourly wages, particularly in the provinces with significant minimum wage increases. Thai workers appear to benefit substantially more than CLM workers, particularly in provinces with the largest minimum wage increases after the policy changes, indicating heterogeneous policy effects and motivating an examination of differential impacts by nationality using the continuous differences-in-differences framework.

Table 2 Regression Result in Overall Combined, Formal, and Informal Sectors

Variables	Overall Combined	Formal	Informal
MWgrowth * Post (2024)	0.430**	0.705**	0.176
	(0.210)	(0.317)	(0.296)
MWgrowth * CLM	-6.512***	-0.334	-8.510***
	(2.428)	(2.396)	(2.675)
Post (2024) * CLM	-0.002	0.099**	-0.061**
	(0.032)	(0.049)	(0.025)
MWgrowth * Post (2024) * CLM	0.168	-3.208**	1.915*
	(1.062)	(1.508)	(1.047)
Constant	3.492***	3.655***	3.463***
	(0.122)	(0.082)	(0.127)
Control	Yes	Yes	Yes
Region Fixed Effect	Yes	Yes	Yes
Observations	21,952	7,992	13,960
R^2	0.227	0.170	0.254
Adjusted R^2	0.226	0.168	0.253

Note: The dependent variable is Log Hourly Wage, and MWgrowth is a continuous treatment variable measuring the change in the statutory minimum wage across provinces, calculated as (MW2024 – MW2022)/MW2022. Standard errors are clustered at the region level and are reported in parentheses. Region fixed effects and control variables are included in the models (coefficients omitted). Continuous difference-in-differences. *Significance at 10% level. ** significance at 5% level. *** significant at 1% level.

Table 2 presents the continuous difference-in-differences regression results on wage responses to provincial minimum wage growth after the policy changes in 2024, across the overall combined and formal and informal sectors separately. The results for (MWgrowth x Post (2024)) indicate that the 2024 minimum wage growth has a positive and significant impact on wages in both the overall and formal sectors, but not in the informal sector. This implies that the wage response to minimum wage growth was concentrated only in the formal sector. The coefficient on the triple interaction term (MWgrowth x Post (2024) x CLM) captures the differential wage response to minimum wage growth between Thai and CLM workers in the post-policy period (2024). There is no significant difference in wages between Thai and CLM workers in the overall regression. Otherwise, the results in the formal sector suggest that the wage response to provincial minimum wage growth is significantly lower for CLM workers (-3.208, $p<0.05$) relative to Thai workers after the policy changes. Interpreting the log coefficient, a 1 percentage

point increase in the provincial minimum wage reduces the wage response in the formal sector by approximately 3.16% for CLM workers relative to Thai workers after the policy change. Moreover, the results in the informal sector also showed that the post-wage response to provincial minimum wage growth for CLM workers is significantly higher, 1.915 ($p<0.10$), compared to Thai workers. For CLM workers, a 1 percentage point increase in the provincial minimum wage increases wage responses in the informal sector by approximately 1.93% relative to Thai workers after the policy change.

Table 3 Regression Result in Small Firm & Large Firm Under Formal and Informal Sectors

Variables	Formal Small Firm	Formal Large Firm	Informal Small Firm	Informal Large Firm
MWgrowth * Post (2024)	0.609**	1.055	0.232	-2.797
	(0.537)	(0.676)	(0.340)	(3.007)
MWgrowth * CLM	-1.779	0.340	-8.669***	-6.091**
	(1.547)	(2.925)	(2.482)	(2.638)
Post (2024) * CLM	0.159***	0.060	-0.049	-0.246
	(0.047)	(0.070)	(0.033)	(0.192)
MWgrowth * Post (2024) * CLM	-5.478***	-1.717	1.296	10.091
	(0.892)	(2.403)	(1.330)	(6.488)
Constant	3.585***	3.773***	3.464***	3.652***
	(0.090)	(0.070)	(0.140)	(0.074)
Control	Yes	Yes	Yes	Yes
Region Fixed Effect	Yes	Yes	Yes	Yes
Observations	3,113	4,879	13,310	650
R^2	0.221	0.162	0.266	0.199
Adjusted R^2	0.215	0.158	0.265	0.172

Note: The dependent variable is Log Hourly Wage, and MWgrowth is a continuous treatment variable measuring the change in the statutory minimum wage across provinces, calculated as (MW2024 – MW2022)/MW2022. Standard errors are clustered at the region level and are reported in parentheses. Region fixed effects and control variables are included in the models (coefficients omitted). Continuous difference-in-differences. *Significance at 10% level. ** significance at 5% level. *** significant at 1% level.

To assess the robustness of the results, the model is estimated for large firms and small firms separately under the formal and informal employment sectors, where small firms have 49 workers, and larger firms have 50 workers or more. There is no significant wage differential between Thai and CLM workers in the larger firms in the

formal employment and large and small firms in the informal employment. However, the results in the small firms in formal employment suggest that the wage response to provincial minimum wage growth is significantly lower for CLM workers (-5.478, $p < 0.01$) relative to Thai workers after the policy changes. A 1 percentage point increase in the provincial minimum wage reduces the wage response in the small firms in the formal sector by approximately 5.33% for CLM workers relative to Thai workers after the policy change. The estimated heterogeneous policy effects remain qualitatively similar across these specifications, suggesting that the main findings are robust to alternative model specifications. The analysis reveals that the impact of minimum wage growth varies across employment sectors and firm size. The observed effects also reflect the spillover effects occurring near the statutory minimum wages, where enforcement is weaker, and there is high noncompliance.

Conclusion

The study examines the impact of Thailand's 2024 provincial minimum wage changes on the real hourly wages of Thai and CLM workers using a continuous difference-in-differences framework. The analysis critically examines whether provincial minimum wage growth affects wages differently between Thai and CLM workers across the formal and informal sectors. The empirical findings suggest that provincial minimum wage growth is associated with heterogeneous wage responses across Thai and CLM and labor market segments. The study tests the analysis overall, formally, and informally separately. Minimum wage growth had a positive and significant impact on wage responses for all workers in the overall and formal sectors; the analysis does not find a statistically significant difference in wage responses to 2024 provincial minimum wage changes between Thai and CLM in the overall analysis. However, the analysis results show that minimum wage policy changes in 2024 are associated with a negative wage response for CLM workers in the formal sector, suggesting that CLM workers benefit less from minimum wage adjustments than their Thai counterparts. In contrast, a positive wage response for CLM migrant workers in the informal sector relative to Thai workers is observed, suggesting that wage adjustments among migrant workers may be more

pronounced in segments of the labor market with weaker institutional coverage and limited access to the social security plan.

Overall, the findings indicate that the policy alone does not appear sufficient to narrow wage differentials between worker groups across sectors, whereas the 2024 minimum wage adjustment addressed wages for Thai and CLM workers in the formal and informal sectors. The results also highlight the role of institutional and structural factors, including labour market segmentation, weak enforcement, and limited access to the social security fund. There are some limitations in this study where the analysis relies on a 2023 pre-policy period due to the availability of nationality identifiers in the Thai Labor Force Survey. In line with previous literature, the study focuses solely on social security coverage to stratify the formal and informal sectors, which may limit the ability to observe the complexity of informal employment. Since the study focuses on the Thai Labor Force Survey, the data do not allow for the precise identification of undocumented migrant workers, which may affect estimates of wage responses among migrant populations.

Discussion

The findings in this study highlight that the impact of the 2024 provincial minimum wage policy varies across worker groups and employment sectors, and that minimum wage growth is associated with positive, significant wage responses for both Thai and CLM workers in the formal sector. The empirical results align with those of Piyapromdee et al. (2024), who analyze the minimum wage hike in Thailand and find significant earnings gains across worker types, albeit with heterogeneity in their magnitudes. They further highlight that wage gains are shaped by labor market reallocation and firm heterogeneity, with low-productivity firms exiting and workers sorting into more productive matches. Overall, the results indicate that the minimum wage policy changes in 2024 appear to have improved wages for all workers, consistent with existing findings (Carpio et al., 2018; Lathapipat & Poggi, 2016; Leckcivilize, 2015).

In the informal sector, the positive, statistically significant wage response to minimum wage growth observed among CLM workers after the policy change indicates that migrant workers are concentrated in low-wage jobs and therefore experience larger marginal wage gains following minimum wage increases than their Thai counterparts.

Conversely, in the formal sector, minimum wage growth is associated with a negative wage response among CLM workers, reflecting that their relative wage gains are significantly lower than those of Thai workers, suggesting the presence of institutional barriers such as unequal enforcement of labour regulations, high noncompliance, limited bargaining power, and differences in contract arrangements. Institutional barriers limit the effectiveness of policy in reducing wage inequality between Thai and CLM workers. Overall, the findings imply that while minimum wage growth can raise wages in some segments of the labour market, it does not narrow wage differentials across nationalities within the labour market segmentation.

Recommendation

The study found that wage differentials exist between Thai and CLM workers in the formal and informal sectors, suggesting that CLM workers are disproportionately represented and experience weaker law enforcement and less consistent benefits. The study's findings suggest several policy implications for improving wage effectiveness and equitable wage distribution in Thailand. Addressing structural drivers, including policies that imply labour market segmentation, is necessary to determine whether minimum wage reforms are to function not only as an income-support mechanism but also as a tool for promoting equity and social justice in Thailand's labour market. The study aims to propose improvements to minimum wage enforcement in provinces with higher CLM concentration and to note the limitations of the Social Security Fund (SSF) registration under Article 40. Also suggests improving migrant labour data systems to analyse the contribution of migrant workers in the Thai labour force. In addition, the study suggests strengthening labour law enforcement and mitigating limitations to SSF registration for migrant workers to ensure that policy impacts are more evenly distributed across worker groups. Finally, the study recommends further research to examine the dynamic effects of minimum wages using panel data or event-study difference-in-differences approaches as additional years of data become available, and to broaden the analysis using employer-employee data.

Acknowledgment

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A Construction of a Mathematical Literacy Diagnostic Test for 9th Grade Students in Chiang Mai Province

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Abstract

This study sought to investigate the current state of deficiencies in mathematical literacy and to construct a specific diagnostic test for 9th grade students in Chiang Mai Province. This study was conducted in two phases. In Phase 1, the researchers conducted a PISA-based survey to identify literacy gaps. The instrument focuses on three core mathematical problem-solving processes: formulating mathematical situations, employing mathematical concepts and procedures for solutions, and interpreting and evaluating mathematical outcomes. The preliminary test was administered to a sample of 385 students via stratified random sampling. The deficiencies of 22 specific areas were revealed from 10 identified behavioral indicators. Phase 2, a four-tier mathematical literacy diagnostic test, consisted of four distinct sections: the first tier is the student's answer; the second tier is confidence in that answer; the third tier is the reasons for the answers; and the fourth tier is confidence in the reasoning provided. This diagnostic test was implemented with a sample group of 100 students. Three versions were developed: Version 1 (Formulating, 15 items), Version 2 (Employing, 20 items), and Version 3 (Interpreting, 15 items). All the test items showed difficulty indices ranging from 0.21 to 0.79 and discrimination indices between 0.20 and 0.72, respectively. In addition, all versions revealed high reliability coefficients of .86, .89, and .78, respectively, and concurrent validity coefficients were established at .82, .82, and .83, respectively.

Keywords: Diagnostic Test, Mathematical Literacy, Mathematical Problem-Solving Process

Background and Statement of the problem

Mathematical literacy serves as a foundational pillar for developing human cognitive systems, offering the structured framework necessary for logical reasoning and creative problem-solving. In addition to the theoretical basis, this competency enables individuals to generate accurate predictions and make informed decisions when navigating the complexities of daily life. Consequently, mathematical literacy is not confined to classroom content; it is defined by the practical application of knowledge to real-world scenarios. This requires a sophisticated integration of skills, including the ability to formulate problems and evaluate situations—an interplay of knowledge and higher-order competencies. To this end, mathematics instruction must be structured to cultivate these specific growth areas through learning processes that prioritize holistic student development. In the context of Thailand, basic education is directed by the Basic Education Core Curriculum B.E. 2551 (Revised Edition B.E. 2560), which manages mathematics into three learning standards. Currently, the learning outcomes of these curriculum indicators were under the benchmarks. It is evident that the national test results for 9th grade students from the academic years of 2022, 2023, and 2024 had mean scores of 24.39%, 25.38%, and 26.53%, respectively. These results show that national averages are still stuck below 30%. In 2024, the scores also varied a lot—ranging from 11.39 to 15.80 points apart. This wide spread in scores highlights a major gap between students who are doing well and those who are struggling.

International benchmarks further highlight these challenges. The 2018 PISA assessment reported a mean mathematics score of 419 for Thai students, which was lower than the OECD average and representing a learning deficiency of two academic years. While 76% of students across the OECD reach Level 2 proficiency or higher, over half of Thailand's students (53%) perform below this baseline. At Level 2, students are expected to interpret and recognize mathematical representations in authentic situations without explicit instruction. By 2022, PISA scores for Thai students declined further to a mean of 394. Long-term data from 2000 to 2022 confirms a statistically significant downward trend in both mathematical and reading literacy (Institute for the Promotion of Teaching Science and Technology, 2020, n.d.; Ministry of Education, 2017; National Institute of Educational Testing Service, 2025; OECD, 2018).

To improve student literacy, contemporary now treats assessment data as the primary driver of student learning. This shift has transformed educational assessment into a rigorous discipline—one that is deeply intertwined with instructional design. We are seeing a clear move away from traditional summative judgments toward "assessment for learning." Within this framework, measurement and evaluation act as indispensable tools that allow educators to calibrate classroom activities to meet specific learning objectives. According to the recent comparisons of O-NET and PISA examination regarding content, cognitive demand, and situational context, it can be concluded that test design can actually drive instructional reform. Furthermore, the analysis of test items is vital for improving critical thinking and problem-solving. Stakeholders must prioritize identifying specific academic deficiencies and learning barriers to drive real achievement.

When examining the educational context of Chiang Mai province the educational hub of Northern Thailand it is evident that the region continues to face challenges in mathematical literacy that align with overall national trends. These challenges are particularly pronounced regarding disparities in educational quality and students' problem-solving skills. According to academic achievement data and local research in Chiang Mai, a significant number of lower secondary school students still lack the ability to connect mathematical knowledge with real-life situations. Consequently, they often develop misconceptions when tasked with solving complex contextual problems (Thongsuk, 2023). Furthermore, operational reports from local educational agencies indicate that the average mathematics scores on the Ordinary National Educational Test (O-NET) among 9th grade students in most schools across Chiang Mai remain at a level requiring urgent improvement. A major contributing factor is that students are accustomed to solving problems using fixed, rote procedures rather than developing a deep conceptual understanding. As a result, they struggle to translate real-world problem situations into mathematical models (Chiang Mai Provincial Education Office, 2023). This phenomenon presents a significant challenge, highlighting the urgent need for a systematic approach to diagnose these learning deficiencies and uncover the root causes of students' mathematical misconceptions within the region.

Accurately identifying weaknesses in mathematics requires carefully designed diagnostic test (Chanchusakun, 2018; Kaewsaiha & Chaisang, 2014). While multiple-choice

tests are popular for their administrative efficiency, they also have limitations. They often fail to show a student's actual cognitive process. Crucially, these formats cannot distinguish whether a wrong answer derived from a lack of knowledge or misconceptions. To overcome this challenge, multi-tier diagnostic assessments are applied to measure more accurate cognitive depth. This started with two-tier tests, which added a "reason tier," and eventually led to four-tier models that include "confidence tiers." These extra layers help researchers verify if a student's response reflects genuine conceptual understanding or just a lucky guess.

The four-tier model is structured into four distinct levels: Tier 1 (Answer), Tier 2 (Confidence in Answer), Tier 3 (Reason), and Tier 4 (Confidence in Reason). The strength of this model lies in its ability to categorize student understanding. For example, an incorrect response paired with high confidence reveals a specific misconception. Conversely, a correct response accompanied by high confidence signifies true conceptual mastery (IEEE, 2025; Li et al., 2024; Tophochanapan, 2022).

To improve mathematical literacy, we must prioritize the development of student problem-solving capabilities. Most mathematical literacy assessments focus heavily on this specific process. It requires the ability to formulate real-world issues in mathematical terms, apply relevant concepts to find a solution, and then interpret those results to solve everyday problems. Any error or deficiency in this process will directly lower a student's assessment outcomes. To address this, our research investigates the current state of mathematical literacy gaps among 9th grade students in Chiang Mai Province. The researchers have developed a four-tier diagnostic test specifically for this purpose. The data from this instrument will inform instructional reforms, ultimately empowering students to reach higher levels of problem-solving proficiency.

Objective

1. To investigate the current state of deficiencies in mathematical literacy for 9th grade students in Chiang Mai Province
2. To construct a specific diagnostic test for 9th grade students in Chiang Mai Province

Conceptual Framework

The conceptual framework of this study, titled "Construction of a Mathematical Literacy Diagnostic Test for 9th Grade Students in Chiang Mai Province," the researcher developed a conceptual framework based on a comprehensive scope of mathematics literacy diagnostic tests and four-tier diagnostic tests. The framework is highlighted as follows:

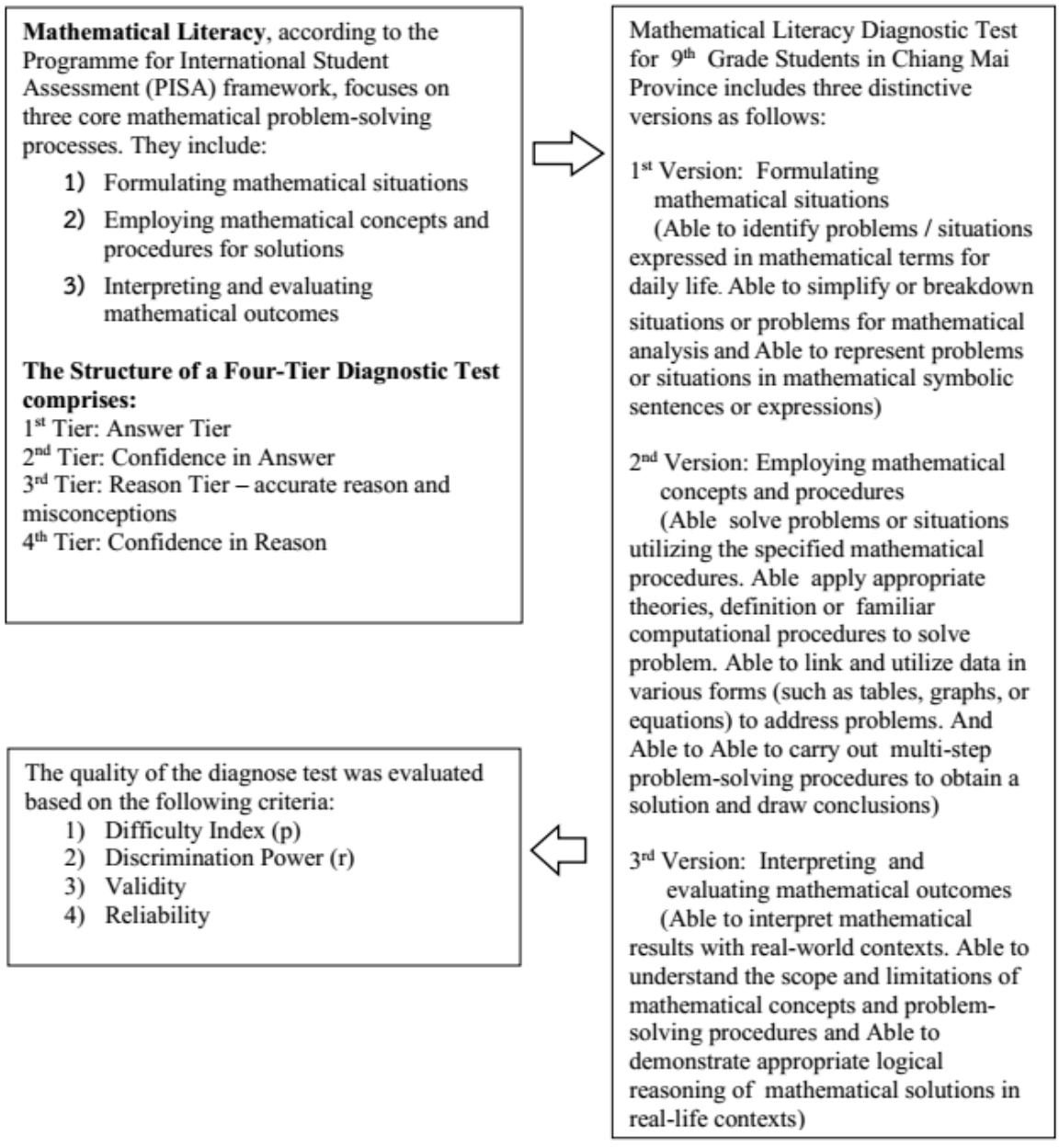


Figure 1 Conceptual Framework

Research Methodology

The research methodology is divided into two phases as the following details.

Research Sample

Phase 1 Sample Group: 385 of 9th grade students in Chiang Mai Province, selected by a multi-stage random sampling technique to mathematical literacy deficiency survey test.

Phase 2 Sample Group: 100 of 9th grade students in Chiang Mai Province, also obtained by a multi-stage random sampling to four-tier mathematical literacy diagnostic test.

Research Instruments

Phase 1 involved a mathematical literacy deficiency survey test. The test is an open-ended format comprising two tiers: the answer tier and the reason tier. and a content validity verification instrument.

Phase 2 involved a four-tier mathematical literacy diagnostic test. The instrument used in this study is a four-tier diagnostic test consisting of four tiers: the answer tier, the confidence of answer tier, the reason tier, and the confidence of reason tier., along with a content validity verification instrument and a criterion-related validity verification instrument.

Data Collection

Phase 1: Investigating the State of Mathematical Literacy Deficiencies among 9th Grade Students in Chiang Mai Province. The procedures were as follows:

1) The researchers reviewed existing mathematical literacy frameworks to conceptualize the problem-solving process within the specified context. This process refers to the sequence of actions through which individuals connect real-world situations with mathematical principles. It involves three key stages: formulating mathematical situations, applying relevant concepts and procedures, and interpreting results. Based on this review, ten behavioral indicators were identified to represent students' problem-solving processes.

2) the derived indicators were used to develop a test blueprint and to construct a survey instrument for investigating learning deficiencies. The test content covered four mathematical domains: quantity, space and shape, change and relationships,

and uncertainty—examined across four contextual categories: personal, occupational, social, and scientific.

3) A panel of five experts reviewed the draft for content validity. This process involved calculating the Index of Item-Objective Congruence (IOC) to ensure each item aligned with the intended learning outcomes.

4) The test items were revised based on the experts' recommendations. The items with an IOC value greater than 0.50 were retained for the final survey test.

5) The survey test was administered to the first sample group, consisting of 385 students, to investigate their mathematical literacy deficiencies. The test was divided into two sets, each consisting of 30 items, for a total of 60 items to prevent testing fatigue and maintain the results' validity. Students were allocated 60 minutes per set for completion.

6) Students' incorrect responses were collected and analyzed to develop authentic distractors for a subsequent diagnostic test. When more than three incorrect response patterns were identified, the three most frequent errors were selected as distractors. When fewer than three errors occurred, additional distractors were constructed based on commonly observed misconceptions. These errors were further classified into specific deficiency types and used to develop the reasoning tier for each item, enabling a more precise diagnosis of students' learning difficulties.

Phase 2: Constructing the Four-Tier Mathematical Literacy Diagnostic Test for 9th Grade Students in Chiang Mai Province. The procedures were as follows:

1) The four-tier multiple-choice diagnostic test was constructed, consisting of the Answer Tier, the Confidence Tier for the answer, the Reason Tier, and the Confidence in reason Tier. The frequent incorrect responses obtained from the Phase 1 survey were create as distractors for both the Answer Tier and the Reason Tier in each test item.

2) A panel of five experts evaluated the draft for content validity. All three versions were determined the Index of Item–Objective Congruence (IOC) between the test items, response options, and underlying reasons and the specified behavioral indicators.

3) According to the experts' recommendations, the researchers revised the test items, response options, and reasons. Items with an IOC value higher than 0.50

were selected for complying into the final four-tier multiple-choice diagnostic test for mathematical literacy deficiencies.

4) The four-tier multiple-choice diagnostic test was tired out with 100 students as the second sample group. The researchers explained all details of the test, response methodology, and its format. Each item consisted of four integrated components: the Answer Tier (A-tier), the Confidence Tier for the answer (CA-tier), the Reason Tier (R-tier), and the Confidence Tier for the reason (CR-tier). Subsequently, the collected data were analyzed the quality of both individual items and the overall test according to criterion-referenced item analysis.

Summary of the Study

The State of Mathematical Literacy Deficiencies among 9th Grade Students in Chiang Mai Province.

The construction of the Mathematical Literacy Diagnostic Test for 9th students in Chiang Mai Province involved the review of the mathematical literacy assessment framework, analyzed, and defined the scope of mathematical processes, and constructed a test blueprint, which was utilized to investigate learning deficiencies. A panel of experts then reviewed for content validity with IOC values ranging from 0.80 to 1.00. After that, the test items were revised in accordance with the experts' recommendations. It had six situational contexts and 60 items and was administered to a sample of 385 students. The incorrect responses were collected from to identify mathematical literacy deficiencies across each behavioral indicator, as presented in Table 1.

Table 1: Mathematical literacy deficiencies categorized by mathematical problem-solving processes and behavioral indicators

Mathematical Problem-Solving Processes	Behavioral Indicators	Mathematical Literacy Deficiencies
Formulating mathematical situations	Able to identify problems / situations expressed in mathematical terms for daily life	Cannot explain the essential components of problem
		Cannot identify mathematical problems embedded within given tasks
		Cannot indicate the key variables in solving problems
	Able to simplify or breakdown situations or problems for mathematical analysis	Unable to determine the mathematical methods for solution
		Unable to identify the relationships between the problem and the provided data
	Able to represent problems or situations in mathematical symbolic sentences or expressions	Unable to translate word problems into mathematical symbolic sentences
		Unable to apply computational methods to visualize mathematical relationships
Employing mathematical concepts and procedures for solutions	Able solve problems or situations utilizing the specified mathematical procedures	Unable to substitute values for variables in a mathematical equation
		Unable to perform simple calculations
	Able apply appropriate theories, definition or familiar computational procedures to solve problem	Unable to select appropriate procedures or data in solving problems
		Unable to perform successful problem-solving procedures
	Able to link and utilize data in various forms (such as tables, graphs, or equations) to address problems	Unable to link available information to solve problems
		Unable to connect the prior knowledge to new knowledge in solving problems
		Unable to solve problems in sequential order
	Able to Able to carry out multi-step problem-solving procedures to obtain a solution and draw conclusions	Unable to apply multi procedures to solve problems
		Unable to interpret mathematical results in real-life contexts
Interpreting and evaluating mathematical outcomes	Able to interpret mathematical results with real-world contexts	Unable to provide supporting reasoning when interpreting results in everyday life contexts
		Unable to indicate the limitations of in formation in everyday life
	Able to understand the scope and limitations of mathematical concepts and problem-solving procedures	Unable to explain what limitations are in the real world
		Unable to provide reasoning to support or challenge mathematical information presented in a problem
	Able to demonstrate appropriate logical reasoning of mathematical solutions in real-life contexts	Unable to identify the methods fail to reflect real-world reality
		Unable to take into account the differences between two distinct problems

As shown in Table 1 demonstrates the alignment among the three core mathematical problem-solving processes, the 10 behavioral indicators, and the 22 identified mathematical literacy deficiencies

Results of Constructing the Four-Tier Mathematical Literacy Diagnostic Test for 9th Grade Students in Chiang Mai Province and Evaluation of the Test Quality

The results of constructing the Mathematical Literacy Diagnostic Test for 9th grade students in Chiang Mai applied a four-tier diagnostic format consists of: (1) Answer Tier, (2) Confidence in Answer, (3) Reason Tier (comprising correct reasons and misconceptions), and (4) Confidence in Reason. The test was constructed based on established mathematical problem-solving processes, which consist of three stages: formulating mathematical situations, applying mathematical concepts and procedures, and interpreting and evaluating outcomes. The content domains were aligned with the mathematics literacy assessment framework of the Programme for International Student Assessment (PISA). Detailed information regarding the test structure and content alignment is presented in Table 2.

Table 2: Showing the number of items for each test version

Version	Number of Indicators	Number of Test Items
1th Version: Formulating mathematical situations	3	15
2nd Version: Employing mathematical concepts and procedures for solutions	4	20
3rd Version: Interpreting and evaluating mathematical outcomes	3	15

As shown in Table 2, the instrument consists of three tests comprising 3, 4, and 3 indicators, with 15, 20, and 15 items, respectively.

2) Results of content validity (IOC), item-objective congruence, criterion-referenced item and test quality, and concurrent validity of a mathematical literacy diagnostic test for 9th grade students in Chiang Mai Province were presented as in Table 3.

Table 3: Item-level and test quality analysis for criterion-referenced assessments, and concurrent validity as evaluated by expert teachers familiar with the sample group

Version	IOC	Difficulty Index (p)	Discrimination Power (r)	Reliability	Validity
1st Version	.60 – 1.0	.21 - .71	.20 - .58	.86	.82
2nd Version	.60 – 1.0	.24 - .79	.20 - .72	.89	.82
3rd Version	.60 – 1.0	.22 - .76	.20 - .48	.78	.83

As shown in Table 3, the criterion-referenced quality of the individual items and the overall assessment across the three tests revealed that the Item-Objective Congruence (IOC) index ranged from .60 to 1.0, the difficulty index from .21 to .79, the discrimination power from .20 to .72, the reliability from .78 to .89, and the validity from .82 to .83.

Summary of the Study

The study on mathematical literacy deficiencies was conducted by developing a diagnostic test derived from the three mathematical processes. The results revealed 22 types of deficiencies across 10 behavioral indicators. The development of the mathematical literacy diagnostic test for 9th grade students in Chiang Mai province was in a four-tier diagnostic format, resulting in three test versions: (1) formulating mathematical situations (15 items), (2) employing mathematical concepts and procedures (20 items), and (3) interpreting and evaluating mathematical outcomes (15 items). The results pointed out that the item difficulty indices ranged from 0.21 to 0.79, and the discrimination indices ranged from 0.20 to 0.72. The reliability coefficients of the three test versions were .86, .89, and .78, respectively, while the concurrent validity scores were 0.82, 0.82, and 0.83. In addition, the criterion-related validity coefficients of the three test forms were .82, .82, and .83, respectively.

Discussions

1. State of mathematical literacy deficiencies: The findings from Phase 1 revealed that 9th-grade students exhibited deficiencies in mathematical literacy across three core processes: Formulating situations mathematically, Employing mathematical concepts, facts, procedures, and reasoning, and Interpreting, applying, and evaluating

mathematical outcomes. A total of 22 specific deficiency characteristics were identified from 10 behavioral indicators.

These deficiencies reflect limitations in mathematical problem-solving, which align with the reports of Thailand's PISA assessments in 2018 and 2022. The reports indicated that the average mathematics scores of Thai students have shown a declining trend and are significantly lower than the OECD average. Notably, over 53% of the students performed below Level 2 (the baseline proficiency level). This phenomenon underscores that students continue to face obstacles in connecting real-world contexts with mathematical knowledge. They are unable to translate problem situations into mathematical models or symbolic sentences, and they lack the skills to interpret outcomes and apply them back to explain the original problem contexts.

A crucial reason why these research findings closely align with the issues highlighted in the PISA assessments is the nature of the evaluation process, which emphasizes "Higher-Order Thinking Skills" rather than mere "Procedural Knowledge." Considering their prior learning contexts, students are often accustomed to solving routine problems with explicit numbers and instructions but lack practice in "Mathematical Modelling" skills. Consequently, they experience cognitive stagnation when confronted with ambiguous and complex real-world problem situations. The findings of this study, therefore, confirm that students are unable to identify mathematical problems from given contexts and cannot interpret meanings for practical application in daily life. These aspects are recognized as the core of Mathematical Literacy, which focuses on applying knowledge to solve problems in diverse situations (OECD, 2018).

Furthermore, these findings are consistent with the research conducted by Kamonthip Toopkham (2022), which examined deficiencies in solving mathematical word problems. The study found that students were unable to analyze the meaning of word problems to distinguish between the given information and what the problem required them to find. Additionally, they could not convert the information and questions into variables, ultimately leading to errors in the substitution and calculation processes. This connection can be explained by cognitive constraints, highlighting that the "translation from natural language to mathematical language" acts as a critical bottleneck hindering the students' learning process. If students cannot overcome the initial hurdle of interpreting

and defining variables, it inevitably triggers a chain reaction, resulting in deficiencies in the subsequent processes of both Employing and Interpreting.

2. Mathematical Literacy Diagnostic Test: The results of Phase 2 in constructing three versions of the four-tier diagnostic test the good quality. The difficulty indices (p) ranged from 0.21 to 0.79, indicating that the test items had appropriate levels of difficulty. The discrimination indices (r) ranged from 0.20 to 0.72. In addition, the reliability coefficients of the three test forms were .86, .89, and .78, respectively, indicating high reliability. The concurrent validity coefficients were also high, with values of .82, .82, and .83 for the three test versions. The findings indicate that the four-tier diagnostic format is a highly effective tool for assessing and diagnosing learning deficiencies. This is consistent with the frameworks of Li et al. (2024), who mention that the inclusion of confidence tiers provides essential verification. Consequently, it distinguishes whether a student's incorrect response stems from a lack of knowledge or misconceptions.

The high reliability and validity of this test suite signify that the instrument can distinguish student cognitive processes with substantially greater precision than conventional multiple-choice assessments. These results align with research by Topochanapan (2022), who used a four-tier diagnostic test to show that adding "confidence tiers" helps stop students from simply guessing. This approach allows students to be more effectively classified according to their patterns of thinking. Crucially, this assessment can tell the difference between a student with a specific misconception and one who just doesn't know the answer. Standard multiple-choice tests usually miss this distinction entirely. Because the tool shows such high reliability, it serves as a dependable way to measure what a student truly understands, moving beyond the surface-level results of traditional testing. Furthermore, the high reliability of this instrument suggests that a four-tier structure can consistently capture a student's true competency and authentic understanding, rather than merely recording surface-level responses. Furthermore, the findings are consistent with the research of Chiranorawanich (2021), who constructed a four-tier diagnostic test on exponents and reported content validity (IOC) ranging from 0.60 to 1.00, with item difficulty and discrimination power within acceptable standards. This confirms that the test development process is initiating from a 'Survey Test' to identify student deficiencies and utilizing them as 'Distractors' in

the actual diagnostic test. It is a highly effective methodology. This test can accurately diagnose students' learning difficulties in authentic learning contexts. Chiranorawanich (2021) also worked on this by creating a four-tier diagnostic test specifically for Algebra. By sorting student understanding into four clear groups—scientific knowledge, Lack of Confidence, Misconceptions, and Lack of Knowledge—this tool does more than just grade a test. It pinpoints the specific gaps in a student's logic, especially where they hold deep-seated misconceptions. This focused support led to a clear boost in academic performance for the students in the 'Misconception' group.

Recommendations

Based on the summary and discussion of the research findings, the researcher provides the following recommendations for the practical application of the results and suggestions for future research.

1. Recommendations for Implementation

Application for Remedial Instruction: educational institutions and 9th grade mathematics teachers should apply these three versions of the Mathematical Literacy Diagnostic Test as tools for pre- test and post-test. This test is effective to categorize students who are just guessing from those who have real misunderstandings. Identifying these specific struggles allows teachers to move past general lessons and build strategies that target actual learning gaps. This method promotes more focused teaching and facilitates students make progress more efficiently.

2. Recommendations for Future Research

Since this study focuses on diagnosis of learning deficiencies, future research should aim to develop and implement instructional innovations to address the misconceptions on 22 areas identified in this study. In particular, it should extend the findings toward the creation of effective innovations for problem remediation.

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Aging and Other Determinants on the Healthcare Burden: A Comparative Analysis of China, Indonesia, Malaysia, and Thailand

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Abstract

The Asia-Pacific region is undergoing a rapid demographic transition, with the population aged 60 and over projected to double from 630 million in 2020 to 1.3 billion by 2050. This shift presents significant challenges for healthcare systems in China, Indonesia, Malaysia, and Thailand, which face increasing pressure from aging populations, urbanization, and evolving socioeconomic conditions. This paper investigates how aging and other determinants contribute to increasing healthcare burdens in these four nations. It specifically examines the influence of demographic transitions on healthcare spending patterns and the effectiveness of respective financing reforms. The study utilizes a comparative analysis of empirical evidence regarding healthcare financing and policy reforms across the four countries. The theoretical framework incorporates the Health-Led Growth Hypothesis (HLGH), Willingness to Pay (WTP), and the relationship between permanent income and household healthcare expenditure. While each country has adopted unique reform strategies, common challenges persist regarding the rising healthcare burden caused by aging societies. Policymakers must prioritize innovative financing mechanisms and expand insurance coverage to ensure sustainable healthcare systems.

Keywords: Aging societies, Healthcare Burdens, Healthcare Policies, and Innovative financing.

Introduction

The Economic and Social Commission for Asia and the Pacific (ESCAP) has reported that the Asia-Pacific region is undergoing rapid changes and an increase in the proportion of older persons. In 2020, approximately 13.6 percent of the population in Asia and the Pacific was aged 60 years or over but this is projected to increase to more

than double, from 630 million in 2020 to about 1.3 billion by 2050. According to the Asia Development Bank (ADB) has reported recently which is in some countries such as the People's Republic of China, Thailand, and Vietnam, this transition will happen very rapidly, and in Indonesia, it will not be as quick but they will end up with very large populations of older persons. Such a change in the population age structure has resulted in wide social and economic consequences like a smaller working-age population, higher dependency among older persons, and a greater demand for welfare and health services. The healthcare systems of China, Indonesia, Malaysia, and Thailand face increasing pressure from aging populations, rapid urbanization, and evolving socioeconomic conditions. Furthermore, Aging is a central determinant of healthcare burdens. Older populations experience higher incidences of chronic diseases and require long-term care services. The mainly analytical question in this paper, how do age and other determinants cause increasing healthcare burdens in these 4 countries? Therefore, this paper will focus on the studies from China to highlight the significant influence of demographic transitions on healthcare spending patterns. Similarly, Indonesia Malaysia and Thailand, with their relatively robust public health systems, face rising challenges in managing aged care and chronic conditions. The first section presents the theory and methodology explaining the link between age, other determinants, and healthcare burdens, the second section presents the empirical evidence there explain to healthcare financing and policy reforms in 4 countries, and the last section presents challenges and future outlook.

This paper addresses the analytical question of how age and other determinants cause increasing healthcare burdens in these four countries? It reviews empirical evidence from China, Indonesia, Malaysia, and Thailand to highlight the influence of demographic transitions on healthcare spending and the challenges in managing aged care and chronic conditions.

Content

1. Theory: the link between age, other determinants and healthcare burdens.

To illustrate the effects of age and other determinants, knowing the channels by which health affects economic growth in general and the extent to which these channels differ between rich and poor countries is important (David E. Bloom et.al,2022) also,

(ALBERT A. OKUNADE et,al 2010) using the household healthcare expenditure (HHEXP) models typically include current (or absolute) income, rather than the theoretically more correct permanent (or long-run) resources, as a core determinant. This practice may arise from difficulties of obtaining an empirically sound proxy or instrument for long-run income. Nonetheless, economic theory posits that household spending decisions rely on their estimated permanent, and not transitory, incomes. Specifically, microeconomic agents tend to consume a constant proportion of permanent income, low income earners have a higher propensity to consume, and higher income earners have a higher transitory income component and a lower than average propensity to consume Microeconomic survey data of individuals and households in advanced and developing countries have been used to study household healthcare expenditure (HHEXP) behaviors.

Besides, the Willingness to Pay (WTP) theory is a central concept in health economics. It represents the maximum amount individuals or societies are prepared to pay for a health improvement or to avoid a health risk. WTP integrates economic behavior, preferences, and constraints to understand how people value health and healthcare services. The willingness to Pay (WTP) is often used to measure the value individuals place on health outcomes, such as reduced mortality risk, improved quality of life, or access to healthcare services. Income levels influence WTP with low-income constraints, individuals may prioritize immediate consumption needs (e.g., food, shelter) over healthcare, even if the health benefits are significant. Also, Individuals' preferences for out-of-pocket spending on personal health interventions can be applied with Private Willingness to pay and societal valuation of public health interventions, often mediated through government as Public Willingness to Pay. In conclusion, Willingness to pay (WTP) is a key conceptual framework in evaluating the economic efficiency of healthcare interventions. For instance, (David E. Bloom et.,al, 2022) found that if the societal WTP for a vaccine exceeds its cost, the intervention is considered economically viable. Conforming to the study's (Caroline Steigenberger et.,al, 2022) WTP also determines the demand curve for healthcare services as for essential services such as emergency care, demand tends to be inelastic, indicating that people are willing to pay more regardless of price.

In the design of health insurance premiums, WTP plays a pivotal role, enabling insurers to assess how much individuals are prepared to pay for coverage against specific risks. In the field of environmental health which based on studied of (Michael Greenstone and B. Kelsey Jack 2015), such as efforts to reduce air pollution, WTP is often employed to estimate the value individuals place on cleaner environments and reduced health risks. Furthermore, preventive measures, including vaccines, frequently rely on public WTP to justify investments. However, the determinants of healthcare spending at the macroeconomic level found the previous studies Gross domestic product (GDP) per capita strongly correlates with healthcare expenditure shows income elasticity near unity in OECD countries (Hansen & King, 1996) and Inflation affects the real value of healthcare spending and accessibility. Wealthier countries often have higher public healthcare spending, while developing economies rely more on out-of-pocket payments. Xu Penghui et al. (2022) found that the health expenditures in China contribute directly to economic growth and produce spillover benefits for neighboring regions and healthcare investments in one region can benefit neighboring regions through increased economic activity as well. At the macroeconomic level, healthcare expenditures are both a result of economic growth and a driver of productivity and development. Understanding the interplay between healthcare spending and economic performance helps policymakers design effective strategies to achieve sustainable growth and equitable health outcomes. Investing in health not only improves individual well-being but also strengthens national economic resilience.

2. Methodology

The health-led growth hypothesis (HLGH) is widely discussed in the existing literature, which suggests a positive correlation between healthcare spending and economic growth. The theory asserts that healthcare expenditures contribute to economic growth by conceptualizing health as a form of capital; investments in health are posited to enhance the accumulation of both human and physical capital, thereby promoting overall economic development since a healthier population implies an increase in the total factor productivity (TFP), a healthier population can work longer, be more productive, secure higher earnings, have higher learning abilities and, in general, enhance the efficiency of the economy's human capital. (Emre Atilgan et,al 2017)

studied in the dynamic relationship between health expenditure and economic growth. (Hao Zhang et al,2022) studies environmental and development economics to address the critical question of why developing nations often suffer from poor environmental quality despite significant health and productivity consequences with using a utility-based framework to analyze consumption, health, and environmental quality trade-offs, focus on quasi-experimental designs, randomized control trials (RCTs), and observational data and found the key findings is Low Marginal Willingness to Pay (MWTP) Despite high environmental costs, households in low-income settings show a surprisingly low willingness to pay for environmental improvements, often due to tight budget constraints and immediate needs. Poor environmental quality leads to severe health issues, reduced life expectancy, and lowered productivity, particularly in developing countries. (Jing Zhao et.,al 2023) studies more economic growth with the better public health? evidence from Western China using utilized the health production function (HPF) to link economic, environmental, and healthcare factors with health outcomes to examined direct and indirect effects via interaction terms with panel data analysis (2003–2020) from Western China. Spatial econometric models (e.g., Spatial Durbin Model, Moran's I index) were used to account for spatial dependence across provinces. Conforming to the studied of (Alfredo R. Paloyo et.,al 2014) with using Randomized Controlled Trials (RCTs) to emphasized as the "gold standard" for evaluating causal effects, RCTs were prioritized for review include both positive (rewards) and negative (penalties) incentives and their impact on weight loss which financial incentives are proposed as mechanisms to align short-term actions (like weight loss efforts) with long-term goals by modifying immediate payoffs. The study (Wuhua Yao et,al 2019) using system-GMM (Generalized Method of Moments) to address potential endogeneity issues and to ensure efficient and unbiased estimation. Based on Grossman's health demand function, which models healthcare expenditure as a function of age and other relevant factors, and further adapts it into a dynamic panel model for analysis.

Therefore, the methodological approaches in microeconomic studies can be used regression models, randomized controlled trials (RCTs), and causal inference methods dominate such as evaluating how changes in insurance premiums affect individual healthcare utilization, and estimating willingness to pay with out-of-pocket policy. In

macroeconomic studies, Time-series analysis, computable general equilibrium (CGE) models, and growth accounting would be appropriated for examining the impact of GDP growth on national healthcare spendings and the intermediate studies were used spatial econometrics, input-output modeling, and analysis of spillover effects for example to investigating how healthcare reforms in one province affect neighboring regions.

The Empirical Evidence

There is a large empirical literature on the age and other determinants link, which we review in this section. As elderly people, they typically require more frequent and specialized medical care, including hospital visits, surgeries, and rehabilitation services especially in long term with aging populations often require support services like assisted living, home care, and nursing facilities. In these countries, they current healthcare system and social support structures may not yet be fully equipped to handle these higher demands for health services. We separate the healthcare financing for 4 countries to explore the empirical evidence.

1. Healthcare Financing and Policy Reforms in China

(Guangya Sun et.al 2024, p3-4) emphasizes, before reforms era in 1949-1978 the Healthcare in China was predominantly state-financed under the planned economy model. The public healthcare was delivered through the "Cooperative Medical Scheme" in rural areas and free medical services for urban workers and civil servants. Chinese government subsidies ensured basic health services, improved life expectancy, and reduced infectious diseases. Next, the economic reform period (1978–2000) with the transition to a market-oriented economy reduced state funding for healthcare. Many hospitals and providers relied on user fees, led to high out-of-pocket (OOP) expenses and disparities in access to healthcare. Unfortunately, the rural cooperative medical scheme in China had collapsed, leaving most rural residents without insurance. After that, solving the problem in reforms era the government reinstated healthcare financing as a priority, introducing public insurance schemes New Rural Cooperative Medical Scheme (NCMS) was launched in 2003 to provide coverage for rural populations. Urban Employee Basic Medical Insurance (UEBMI) was started in 1998 for urban workers and the program to Urban Resident Basic Medical Insurance (URBMI) was introduced in 2007 for

non-employed urban residents to coverage Chinese people by 2011, more than 95% of the population had basic health insurance. To achieve comprehensive governance of China's HCS, a holistic healthcare reform pilot program, known as the Comprehensive Medical Reform (CMR), was initiated in 2015 to address systemic challenges like unequal access, high Out-Of-Pocket healthcare burdens, and inefficiencies in service delivery. (Guangya Sun et al,2024) The empirical results demonstrate that the implementation of CMR does not have a statistically significant influence on the overall medical expenditure and the total medical expense ratio. However, it significantly reduces the out-of-pocket medical expense and the out-of-pocket medical expense ratio, while also improves the health status of individuals. Further analysis reveals that CMR has a positive effect on medical satisfaction and level, as well as an increased likelihood of choosing lower-grade hospitals and expanding the coverage of health insurance. The medical or healthcare burden is an important indicator of residents' ability to pay for medical services and is closely related to economic inequality, which in turn affects health inequality. The literature has focused on residents' medical burden from the perspective of medical expenditure, with many scholars suggesting that insurance can reduce the healthcare burdens. In long term strategy for the Chinese government to ensure universal health coverage and promote public health will focus on disease prevention, health education, and integration of traditional Chinese medicine also financial incentives and insurance policies support the redirection of healthcare demand to primary care providers.

(Jing Zhao et,al 2023) emphasizes that the economic growth significantly improves public health outcomes, notably reducing human mortality in Western China. Also, an "inverted U"-shape curve exists between human mortality and GRP per capita in Western China. Particularly, economic growth will significantly reduce human mortality during the range of sample data besides the public health improvements in one province positively affect neighboring provinces, showcasing strong spatial spillover effects.

(Wuhua Yaoa,2019) emphasizes whether education influences healthcare expenditures in China, considering the country's rapid educational expansion and low healthcare spending relative to GDP. They founded that the education quantity has an insignificant impact; otherwise, education quality positively influences healthcare expenditures.

2. Healthcare Financing and Policy Reforms in Indonesia

Indonesia faced a critical healthcare crisis its less than half its population was financially protected, out-of-pocket spending was high, comprising 45 percent of the current health expenditure rendering healthcare unaffordable for many, and worsening health disparities. To address this, the Government of Indonesia launched the National Health Insurance, Jaminan Kesehatan Nasional (JKN), scheme to achieve universal healthcare coverage (UHC). The JKN scheme saw remarkable expansion over short span of time, covering over 260 million people, or more than 95 percent of the population, by December 2023. Physical access to health services in Indonesia is considered adequate, although there are shortages in the number and distribution of health professionals. With more than 8,000 public health centers (1 for every 23,000 people), a wide outreach system, and more than 1,250 public and private hospitals, access to services is good in all but remoter areas. However, the quality of infrastructure, functionality of equipment, and availability of supplies are often key problems. There are too few doctors, especially specialists, and this will be a major issue with future noncommunicable disease (NCD) needs expanding rapidly. Not only are there too few doctors and specialists, they are also very inequitably distributed across Indonesia. This transformed Indonesia's healthcare landscape, reducing financial barriers to healthcare, and lowering out-of-pocket expenses to 27.5 percent of current health expenditure (Augustine Asante and et al ,2023) After policy reforms, the findings are the overall financing system shifted from moderately progressive in 2018 to mildly regressive in 2019. Indirect taxes and social health insurance were regressive in 2019, to place a greater burden on lower-income groups. Not only, out-of-pocket payments were progressively distributed but indicated potential unmet healthcare needs among low-income groups but also, People with low income had higher financial burdens but received fewer healthcare benefits compared to wealthier groups. In healthcare access, especially in rural areas, remained a significant challenge. Conform to the findings (Riska Dwi Astuti et al, 2022) an evaluation analysis of the subsidized health insurance program impact in this study indicate that the program has little impact on the utility of health facilities by its recipients the average difference between outpatient and inpatient visits between poor people who are subsidized insurance recipients and poor individuals without insurance is less than 1 visit.

The reform roadmap in Indonesia, particularly in the context of healthcare financing, outlines the strategic direction and policy measures required to transition toward universal health coverage (UHC) while addressing challenges in equity, efficiency, and sustainability.

3. Healthcare Financing and Policy Reforms in Malaysia

Malaysia is coming under increasing pressure to control the escalating healthcare burden to ensure the adequacy of future healthcare funding. Malaysia, therefore, is considering a new national health financing scheme in order to strengthen health financing and to face future challenges. (Kevin Croke et al, 2019) examined efforts at health financing reform in Malaysia over 35 years, seeking to identify why health financing reforms were continuously proposed by the government but consistently blocked by opponents and the findings are Malaysia has achieved near-universal access to public healthcare funded through general taxation, ensuring significant financial protection, particularly for the rural poor and public services are highly subsidized, with minimal out-of-pocket costs, symbolized by the low RM 5 (~$1) fee for public healthcare services. Otherwise, the multiple attempts to introduce comprehensive financing reforms, including insurance-based systems such as the one care initiative, were blocked due to public resistance and interest group opposition, and public perception, shaped by historical successes in affordable healthcare, views reforms as a potential threat to the low-cost system, creating political resistance to change caused to failed to reforms in Malaysia

4. Healthcare Financing and Policy Reforms in Thailand

The 1997 Asian financial crisis had a profound effect on healthcare spending, with reduced household incomes lead to a significant decline in Out-Of-Pocket healthcare expenditures in Thailand, and the major source of personal healthcare financing in most developing countries, is notably burdensome for poor households (ALBERT A. OKUNADE 2010) found that out of pocket payments are the main method of healthcare financing in Thailand, disproportionately burdening lower-income households especially, in poor households often liquidate assets or incur debts to meet essential healthcare needs, underscoring the need for improved financial risk protection. The health care system is financed through a mix of sources, namely, general taxes, social health insurance

contributions, private insurance premiums, and a low level of direct out-of-pocket payments constituting approximately 18 percent of total health expenditure in 2008. Completing geographical coverage of the healthcare infrastructure was achieved through intensive investment in public healthcare infrastructures by the early 2000s, although an inequitable distribution of health resources remains a problem. Public hospitals, are mainly owned by the Ministry of Public Health. In the 2000s, Thailand's healthcare financing and policy reforms stand out as a global example of achieving universal health coverage (UHC) in a lower-middle-income country. Over the decades, Thailand transitioned from targeted programs for low-income and vulnerable groups to a universal coverage scheme. This success was underpinned by strategic investments in healthcare infrastructure, human resources, and evidence-based policy reforms. The reforms have significantly improved health outcomes, particularly for rural and low-income populations, by ensuring access to essential healthcare services. The integration of various health financing schemes, including social health insurance for formal sector employees and tax-financed coverage for the informal sector, has reduced out-of-pocket expenses and financial barriers. Despite these successes, challenges persist. Demographic shifts, such as an aging population, and the growing burden of non-communicable diseases demand further innovation in healthcare delivery and financing. Additionally, ensuring the fiscal sustainability of the UHC system while maintaining equitable access remains a critical priority.

Challenges and Future Outlook

As the data launched recently show, Thailand is one of the countries with the lowest birth rate. If the government lets continuity be a determinant of healthcare expenditure, it captures the financial constraints and adaptive behaviors of households in the face of health liabilities. out-of-pocket (OOP) payments are the main of healthcare financing in Thailand, reflecting significant financial burdens, particularly for lower-income groups. There is a need for innovative financing mechanisms, including insurance and subsidies, to reduce reliance on Out-Of-Pocket payments and alleviate financial burdens on households. In addition, the healthcare policies should address the regional and demographic disparities in healthcare access and expenditure, ensuring equitable

healthcare services for all Thai people along with to investment in preventive care and health education can potentially reduce long-term healthcare burdens and improve overall population health. While the CMR in China effectively reduces medical burden and improves health outcomes, demonstrating that comprehensive, integrated healthcare reforms can address economic and health inequalities conform to (Guangya Sun et al, 2024). Also, the success of CMR pilot regions provides a scalable model for nationwide implementation and potentially for other countries with similar healthcare challenges. With elderly people in China, the reform must consider the rising demand for medical care among the elderly and address their specific needs without increasing their financial burdens. while retirement generally has positive effects on subjective health and healthcare utilization (Clémentine Garrouste et al, 2020), the refinement impacts on cognitive and physical health focus on the need for targeted policies. In case other determinants effect to healthcare burden which leading to NCDs diseased (Nathalie Mathieu-Bolh,2020) the findings links between income and obesity and nutrition patterns suggests that low- and high-income individuals make different food consumption choices and as a consequence, react differently to policy incentives.Also, (Alfredo R. Paloyo et,al 2014) emphasizes the obesity and overweight are linked to diseases that cost society a significant amount of resources. While behavior modification can reduce the problem, instigating such lifestyle changes is an uneasy task. One potential way to reduce the problem is through the use of financial incentives. The implications of age and other determinants on healthcare burdens, people who are concerned healthy issues will concern and realize have to be high income people with easily to access the healthcare services especially in the out of pocket payment countries as Indonesia and Thailand.

Conclusion

In conclusion, while each country's healthcare reforms reflect their unique contexts, lessons in stakeholder engagement, evidence-driven policymaking, and prioritization of equity can guide future efforts globally. The potential effects of health reform as (Martin Gaynor et al,2015) state that "the primary objectives of the ACA are to expand health insurance coverage and provide incentives for health-care providers to reduce costs. Changes in market structure introduced to support these objectives could

affect quality, prices, and costs through numerous mechanisms", several of which are suggested by the findings in the literature reviewed above. For example, Health Insurance Exchanges (HIEs) are being established to provide a forum where consumers who do not have access to large-or small-group health insurance through their employers can access health insurance with low search costs. In addition, they are intended to play a role in risk pooling and to facilitate competition between health insurers with the goal of generating reduced prices and increased coverage. In case of 4 countries are facing on aging society and other determinants tend to increase the healthcare burdens, if we would like to reduce the healthcare burdens or out-of-pocket payment, the policymaker should launch the program will coverage by insurance and prepare the healthcare system to be better.

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The Role of Tobacco Control Change Agents in Slowing the Spread of E-cigarettes in Thailand: An Analysis based on Diffusion of Innovations Theory

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Abstract

This study examines the mechanism of e-cigarette diffusion among Thai youth under the Diffusion of Innovations (DOI) framework. The objectives are to analyze factors based on DOI theory affecting the epidemic, synthesize the roles and strategies of tobacco control workers (Change Agents) in slowing the spread, and analyze related policy gaps. This is qualitative documentary research utilizing content analysis and policy analysis of policy documents, research, situation reports, and campaign media published between 2018–2024 (B.E. 2561–2567). The findings indicate that e-cigarettes possess all attributes under the DOI framework, which include relative advantage, compatibility, low complexity, trialability, and observability, which facilitate rapid adoption among youth. Change Agents, including teachers, Village Health Volunteers (VHVs), public health officers, community leaders, and local administrative organizations, play a crucial role in slowing diffusion. Their strategies include reducing the perceived advantage of e-cigarettes, reducing compatibility by creating positive identities for non-smokers, and increasing the perception of long-term harms and risks. However, operations face significant policy gaps: the gap between total ban policies and enforcement in online markets, the gap in the capacity of Change Agents, and the strategic communication gap that aligns poorly with youth media culture.

The discussion suggests that DOI theory effectively explains the diffusion of negative innovations, leading to the proposal of a "counter-diffusion strategy" to develop modern preventive measures. Recommendations include developing mechanisms to regulate online

markets, enhancing the digital competencies of Change Agents, adjusting communication strategies to be participatory and youth-led, and integrating e-cigarette control policies with national digital policies.

Keywords: E-cigarettes, Diffusion of Innovations (DOI), Tobacco Control Change Agents, Health behavior.

Background and Statement of the problem

Over the past decade, Thailand has experienced a rapid increase in e-cigarette use among children and youth, despite having strict control laws regarding import, sale, and possession (Ministry of Commerce, 2014; OCPB, 2015; Ministry of Finance, 2017). Data from the Tobacco Control Research and Knowledge Management Center (TRC) (2023) indicates that usage rates in some areas exceed 17%, reflecting a concerning epidemic level. Key factors include access via online media, "Toy Pod" product designs that attract youth, and misconceptions regarding the safety of e-cigarettes. These characteristics can be explained through Rogers' (2003) Diffusion of Innovations (DOI) theory, which states that e-cigarettes possess attributes facilitating adoption: relative advantage, compatibility with adolescent lifestyles, ease of use, and high observability, causing the product to spread rapidly beyond the control of legal measures alone.In the Thai context, successful tobacco control requires local-level mechanisms through the role of Tobacco Control Change Agents, such as teachers, Village Health Volunteers (VHVs), Sub-district Health Promoting Hospitals (Or Sor Mor), community leaders, and Local Administrative Organizations (LAO). These agents function to communicate risks, monitor high-risk areas, establish social norms, and support local enforcement. However, most research in Thailand focuses on youth as users rather than systematically analyzing the role of Change Agents under the DOI framework, resulting in a lack of in-depth knowledge regarding the working mechanisms of local personnel in slowing the spread of e-cigarettes.

Therefore, studying the role of tobacco control workers in slowing the e-cigarette epidemic is essential for both academic purposes, to fill knowledge gaps, and policy dimensions, to support the development of area-based prevention measures

consistent with the current situation, leading to enhanced protection of Thai youth from increasingly complex risk behaviors.

Objectives

1. To analyze factors affecting the spread of e-cigarettes among Thai youth according to the Diffusion of Innovations (DOI) framework.
2. To synthesize the roles, working processes, and communication strategies of tobacco control workers (Change Agents).
3. To analyze obstacles, limitations, and policy gaps in e-cigarette control measures.

Conceptual Framework

This research framework is synthesized from domestic and international literature, applying Rogers' (2003) Diffusion of Innovations (DOI) theory alongside Innovation Resistance Theory. This framework is used to analyze the mechanisms that Tobacco Control Change Agents can use to slow or undermine the spread of e-cigarettes among Thai youth, which are a modern tobacco product spreading rapidly with innovative attributes favorable for adoption. The framework consists of three key components as follows;

1) Independent Variables: These reflect the role of Change Agents at the local level, divided into three aspects: (1) Educator role to communicate scientific data and correct misconceptions about safety; (2) Surveillance role to monitor risk behaviors and connect users to treatment services; and (3) Social Enforcer role aimed at setting community norms and rules to reduce the legitimacy of e-cigarette use in areas such as schools and public spaces.

2) Mediating Variables: These represent the youth's perception of e-cigarette attributes as an innovation. The operations of Change Agents are expected to adjust perceptions in three dimensions: reducing the perceived relative advantage of e-cigarettes compared to cigarettes, increasing perceived health and legal risks, and reducing the compatibility between e-cigarettes and modern youth culture/identity.

3) Dependent Variables: These reflect the adoption or resistance behaviors of youth, covering two forms: Delayed Adoption and Innovation Resistance/Rejection.

These behavioral changes indicate the effectiveness of Change Agents in slowing the diffusion process locally.

Research Methodology

This study is qualitative documentary research aiming to examine the diffusion mechanism of e-cigarettes among youth under the DOI framework and analyze the role of local Change Agents. The primary methods employed are content analysis and policy analysis. All data were derived from secondary documents, with no direct human data collection.

1) Data Sources Data sources include policy documents, academic articles, public health situation reports, and campaign media or manuals related to the work of teachers, Village Health Volunteers (VHVs), and local administrative organizations. Documents were selected based on relevance, credibility, accuracy, and currency, focusing on materials published between 2018–2025 (B.E. 2561–2568) to reflect the current situation.

2) Data Collection and Analysis Data collection involved searching databases including ThaiJO, PubMed, Scopus, Google Scholar, and official government websites. The analysis involved content analysis to extract key data, thematic analysis to group findings, policy analysis to assess measure effectiveness, and conceptual synthesis to link data to the theoretical framework. Data quality was verified using triangulation, audit trails, and expert consultation to reduce interpretation bias.

Research Results

Current Situation and Trends of the E-cigarette Epidemic among Thai Youth

An analysis of documents published between 2022 and 2024 shows a serious problem, as e-cigarette use among Thai youth has become a widespread epidemic. This crisis is defined not just by the volume of users, but by the rapid evolution of the products and the demographics they attract. Most alarmingly, the prevalence rate among high school and vocational students in certain urban areas has surged to between 17.6% and 30.4%. This represents a more than threefold increase in just five years compared to 2018 data, with vocational students currently engaging in the behavior at nearly double the rate of general education students. This surge correlates

with a calculated shift in product design. The market has transitioned almost entirely from complex refillable systems to disposable "Toy Pods," which now account for over 80% of youth usage. These devices are dangerous specifically because they are accessible and deceptive; priced as low as 150–300 THB, they are designed to resemble stationery or cartoon characters, allowing students to hide them in plain sight from parents and teachers. Furthermore, the demographic profile of the "typical smoker" is changing. While smoking was historically male-dominated, the arrival of pastel-colored devices and fashion-oriented marketing has successfully courted female youth, narrowing the male-to-female ratio to approximately 1.2:1. Fueling this entire ecosystem is an unregulated "online black market." Platforms such as Twitter/X, TikTok, and Line OpenChat have become virtual storefronts where direct sales and Cash on Delivery (COD) services operate freely, by-passing age verification laws entirely.

Analysis of Diffusion Factors under the DOI Framework

To understand why these products have spread so effectively, one must look through the lens of Rogers' (2003) Diffusion of Innovations (DOI) theory. Rogers posits that five specific attributes determine how quickly a new idea or product is adopted. In the context of Thai youth, e-cigarettes have been engineered to hit every single one of these triggers as Table 1 summarizes the application of these attributes to the Thai context.

Table 1 Application of DOI Innovation Attributes to E-cigarette Diffusion in Thai Youth

Innovation Attribute (DOI)	Application to E-cigarettes in Thai Youth	Effect on Diffusion
1. **Relative Advantage**	Youth perceive e-cigarettes as "safer" than cigarettes, having no smoke/smell, appearing cheaper per use, and having a modern image.	Accelerates adoption and trial as they are viewed as less risky and "cooler" than cigarettes.
2. **Compatibility**	E-cigarettes are integrated into digital lifestyles such as TikTok clips, subculture belonging, and relationship building.	Reduces psychological resistance, making smoking "normal" in youth social circles.
3. **Complexity**	New models, especially disposable pods, are very simple to use (unwrap and use immediately) and portable.	Lowers barriers to entry, allowing even youth with no smoking experience to try easily.
4. **Trialability**	Low price, sharing among friends, and access to informal trial sources lower the cost of the "first try."	Results in a higher initiation rate compared to traditional tobacco products.
5. **Observability**	High vapor volume, pleasant scents, and widespread reviews on social media make it highly visible.	Creates motivation to imitate and spreads usage rapidly within youth social networks.

Roles and Strategies of Tobacco Control Change Agents

Synthesis of manuals and reports reveals that Change Agents (teachers, VHVs, community leaders) play a role as "Linkers to Desirable Health Innovations." They promote life skills, creative community activities, and social measures like "Smoke-Free Sub-district Health Charters". Furthermore, they employ specific strategies to counter the DOI attributes of e-cigarettes, as detailed in Table 2.

Table 2: Strategies Countering DOI Attributes of E-cigarettes

DOI Attribute	Change Agent Strategy	Perception Modification Goal
1. Relative Advantage	Expose the "safer" myth with data; exhibits/clips on long-term effects of nicotine salts.	Decrease Relative Advantage
2. Compatibility	"New Gen Loves Health, Not Smoke" campaigns promote a new identity where "Not smoking is truly cool."	Decrease Compatibility
3. Complexity	Emphasize the "hidden complexity of danger" such as addiction.	Increase the Complexity of Harm
4. Trialability	Create environments reducing trial opportunities (School/Community Watch); reinforce refusal skills.	Decrease Trialability (Increase difficulty)
5. Observability	Create "visible" alternative online content for successful Gen Z non-smokers.	Counter Observability

Cross-Case Analysis and Policy Gaps

A cross-case analysis of the current tobacco control landscape reveals three profound structural and operational gaps that undermine the efficacy of prevention efforts. These deficiencies highlight the disconnect between legislative intent and the practical realities of the evolving e-cigarette epidemic.

Foremost among these challenges is the Policy–Enforcement Gap. Although Thailand ostensibly enforces a "total ban" on electronic cigarettes, a stark dichotomy exists between the strict prohibition in physical spaces and the permissive environment of digital markets. While offline channels are relatively contained, online platforms operate with little oversight. This enforcement failure is exacerbated by the fragmentation of authority across various agencies, which include the Office of the Consumer Protection Board (OCPB), the Customs Department, and local administrative bodies. The lack of a unified command structure and proactive coordination among these entities creates jurisdictional ambiguities that allow illegal online trade to flourish. Simultaneously, a

Capacity Gap significantly impedes the effectiveness of frontline Change Agents. Teachers and Village Health Volunteers (VHVs), who are central to community-based prevention, are often burdened with existing responsibilities and lack continuous training regarding the rapidly evolving nature of e-cigarette products and marketing tactics. Furthermore, schools and communities frequently suffer from resource constraints, preventing the production of modern, appealing media content that resonates with youth. Consequently, in the absence of adequate counseling skills and resources, institutions often revert to punitive measures, which address the symptom rather than the root cause of addiction.

Finally, a Strategic Communication Gap persists in how prevention messages are disseminated. Current communication strategies rely heavily on a "top-down" approach that utilizes "fear appeals" to deter usage. This method often proves ineffective as it conflicts with the adolescent psychological construct of the "personal fable," the belief in one's own invulnerability and uniqueness. By failing to integrate behavioral insights or include youth participation in the design of health messaging, current campaigns often alienate the very demographic they aim to protect, widening the distance between health authorities and at-risk youth.

Summary of the Study

This study investigates the causes behind the rapid spread of e-cigarettes among Thai youth and evaluates the response from tobacco control networks. The results confirm that the "epidemic" is driven by how well e-cigarettes fit the five criteria of Rogers' Diffusion of Innovations (DOI) theory. Specifically, these products appeal to youth because they offer a relative advantage (appearing safer and modern), fit well with digital lifestyles (compatibility), are easy to use (low complexity), are cheap to try (trialability), and are highly visible on social media (observability). The research also focuses on the essential role of local Change Agents, such as teachers, Village Health Volunteers (VHVs), and community leaders. These individuals act as the community's primary defense. Their strategy involves "counter-diffusion," or slowing the trend by correcting safety misconceptions, establishing social norms that value non-smoking, and enforcing local rules to limit access.

However, the discussion identifies three major barriers that limit the effectiveness of these efforts:

1. The Policy–Enforcement Gap: There is a disconnect between strict laws (a total ban) and the reality of unregulated online markets.
2. The Capacity Gap: Frontline workers often lack the necessary resources and modern digital skills to keep up with changing products.
3. The Strategic Communication Gap: Current prevention campaigns rely heavily on "fear appeals," which often fail to influence the behavior of young people.

Theoretically, this study demonstrates that perception is often more powerful than fact when youth decide to adopt a new product. Practically, the findings suggest that a shift in strategy is needed. Instead of relying solely on punishment, policymakers should adopt a "Counter-diffusion Strategy" that empowers youth and equips Change Agents with the tools needed to address the problem in the digital age.

Discussions

The findings of this study offer critical theoretical and practical insights into the mechanisms driving the e-cigarette epidemic among Thai youth. Theoretically, the research confirms that Rogers' Diffusion of Innovations (DOI) theory is not only applicable to beneficial technologies but also serves as a powerful framework for explaining the spread of "negative innovations." The rapid adoption of e-cigarettes in Thailand validates the premise that adoption is driven less by the objective safety of a product and more by its perceived attributes. For Thai youth, e-cigarettes have successfully masqueraded as a "superior innovation" to offer the perceived relative advantages of safety, social status, and modernity over combustible tobacco. This suggests that future prevention efforts cannot rely solely on factual health warnings; they must actively dismantle these positive perceptions, essentially employing a "counter-diffusion" strategy that re-frames non-smoking as the true innovation.

Practically, the study highlights a necessary paradigm shift for Tobacco Control Change Agents. The current analysis reveals that while the structural network of teachers, Village Health Volunteers (VHVs), and community leaders is robust, their traditional role as "enforcers" is becoming obsolete in the digital age. The "Controller"

model, which focuses on bans and punishment, struggles to compete with the agile, youth-centric marketing of the e-cigarette industry. The discussion points towards a need for these agents to evolve into "Facilitators" and "Empowerers." By shifting the focus from suppressing behavior to building digital literacy and resilience, Change Agents can partner with youth to co-create protective social norms, rather than imposing them from above.

Finally, at the policy level, the persistence of the "epidemic" despite strict legal bans exposes the limitations of a fragmented control system. The study underscores that the battleground has shifted from physical storefronts to a complex digital ecosystem comprising social commerce, logistics, and influencers. The "Policy–Enforcement Gap" discussed here in suggests that successful control requires "ecosystem governance." This entails moving beyond siloed health policies to integrate with national digital economy frameworks, ensuring that online platforms and logistics providers are held accountable as gatekeepers. Without this structural integration, local efforts by Change Agents will remain a temporary fix to a systemic problem.

Recommendations

1. Develop legal frameworks and a specific unit for online e-cigarette market regulation with authority over social media, payments, and logistics.
2. Integrate control policies with National Digital Policies, embedding digital and media literacy in education curricula.
3. Allocate targeted budgets via local health funds for continuous local prevention projects.

Acknowledgment

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Trust Formation across Academic Disciplines: The Role of Thought Styles in Interpreting Leadership Behaviors

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Abstract

This study examines how disciplinary thought styles influence trust formation in Humanities and Social Sciences (HSS) collaborations. The objective of this study is to explain how disciplinary cognition shapes the interpretation of leadership behaviors and to test whether modeling discipline as a cognitive filter improves predictive accuracy. We develop a framework that treats thought styles as cognitive filters that shape how leadership behaviors are interpreted as trust signals across different academic disciplines. The approach measures thought styles through psychometric scales and models their filtering effects on multimodal behavioral signals using path analysis with multigroup structural equation modeling. The research adopts a quantitative design based on multimodal behavioral data and survey measures, with purposive sampling of interdisciplinary research teams. An empirical study with 42 research teams (History and Sociology) demonstrates that identical leadership behaviors elicit different trust perceptions across disciplines, with historians responding more to contextual detail and temporal framing, while sociologists prioritize theoretical integration and methodological transparency. The framework shows improved predictive accuracy compared to models treating disciplines as simple covariates. The proposed model showed good fit (χ^2/df = 1.32, CFI = 0.96, RMSEA = 0.04, SRMR = 0.05) compared to baseline (χ^2/df = 2.81, CFI = 0.82) and covariate models (χ^2/df = 2.15, CFI = 0.88). These results confirm that disciplinary thought styles function as active filtering mechanisms that systematically condition trust formation and team effectiveness. These findings suggest that accounting for disciplinary cognitive diversity may enhance our understanding of trust dynamics in interdisciplinary academic collaborations.

Keywords: Trust Formation, Interdisciplinary Collaboration, Disciplinary thought Styles, Leadership Behaviors, Team Effectiveness, Academic Collaboration

Introduction

In HSS (Humanities and Social Sciences) interdisciplinary collaboration, trust is conveyed and interpreted through multimodal signals rather than verbal content alone, and disciplinary cognitive and normative differences shift the meaning and weight of those signals. Organizational trust measures and contextual validity provide the starting point (Gillespie, 2011), while physiological and nonverbal cues show that trust is richly multimodal (Ajenaghughrure et al., 2020; Burgoon et al., 2021). In academic settings, these cues are embedded in discipline-specific practices, roles, and procedures (Seashore et al., 2010) and shape performance via collaborative culture and knowledge-sharing mechanisms (Nauman et al., 2022). Consequently, when leaders enact the same behavior in cross-disciplinary teams, members from different fields can infer different levels of trustworthiness and cooperative intent from the very same multimodal cues.

At the cognitive level, dual-process and metacognitive perspectives explain how intuitive and analytic systems govern evidence evaluation and the monitoring of decisions (B. S. Kim et al., 2025; Patent, 2022), and implicit social cognition clarifies why rapid, automatic trust judgments are pervasive (Nosek et al., 2011). These mechanisms couple with disciplinary "thought styles": relatively stable, measurable differences across fields in admissible evidence, argumentative organization, and knowledge legitimation (Berger & Luckmann, 2016; Fleck, 1981; Huber, 1990). When such differences meet multimodal trust cues, they implement a practical filtering process (Ajenaghughrure et al., 2020; Burgoon et al., 2021). Moreover, HSS institutional and cultural boundaries—including gendered marginality, incentive regimes, regional knowledge production, and classification choices—constrain this filtering (Arhiliuc & Guns, 2023; Bertolini et al., 2018; Guzmán-Valenzuela et al., 2023; Kueffer & Wiedmer, 2022; Mohit et al., 2024; Pearse et al., 2019; Xu, 2021; Zhe et al., 2021).

Methodologically, many studies treat "discipline" as a covariate or grouping label for convenience, but this obscures the mechanism: why do identical leader behaviors elicit different trust inferences across fields? The consequences appear not

only as averaged-out effects but also as misattribution of missingness mechanisms and variance sources—when response behavior is systematically conditioned by thought style, assuming randomness induces bias (Little & Rubin, 1989). Related evidence on leadership–learning links and on the differentiation of academic communities (Hymes, 1961; Leithwood & Seashore-Louis, 2011; Merton, 2005) together suggest that if we keep treating discipline as a "label" rather than a "filter," we cannot explain heterogeneous interpretations of isomorphic behaviors.

We therefore systematize a scale ⟶ encoding ⟶ gating ⟶ aggregation pipeline: first, psychometrically measure dimensions of disciplinary thought style (Kovács et al., 2021); next, behaviorally encode leaders' text/voice/face multimodal signals; then gate those signals with the discipline's thought-style vector; and finally aggregate over interaction networks to team-level trust and effectiveness. We compare the proposed specification with baseline and "discipline-as-covariate" models and use university–community collaboration and project-team evidence as external touchstones (Bland et al., 1999; Nauman et al., 2022). Unlike generic leadership models that omit disciplinary contingencies (Moran, 2023), this design preserves identifiability while testing the incremental value of modeling "discipline as filter."

Building on this theoretical and methodological gap, the present study reconceptualizes discipline not as a passive covariate but as an active filtering mechanism that shapes how multimodal leadership signals are interpreted in HSS interdisciplinary collaboration. Accordingly, this study addresses the following research questions: (RQ1) How do disciplinary thought styles filter and transform leaders' multimodal signals into trust perceptions? and (RQ2) Does modeling discipline as a filtering mechanism improve the prediction of team trust and effectiveness compared to baseline and discipline-as-covariate approaches? We further expect that disciplinary thought styles will systematically condition the relationship between leadership behaviors and trust, and that the proposed filtering model will provide superior explanatory and predictive performance relative to conventional specifications.

Research Objectives

1) To develop a theoretical and empirical framework that models disciplinary thought styles as cognitive filters in interpreting multimodal leadership signals.

2) To compare the explanatory and predictive performance of three models: (1) baseline model, (2) discipline-as-covariate model, and (3) thought-style filtering model.

3) To examine how disciplinary thought styles condition the relationship between leadership behaviors and trust formation, including differences between History and Sociology teams and their implications for team-level effectiveness.

Literature Review

This section reviews existing research on trust dynamics, leadership behaviors, and disciplinary cognition in academic collaborations. The literature clusters around three main themes—(1) trust measurement and signaling in professional contexts, (2) leadership effectiveness in academic settings, and (3) disciplinary epistemology and thought styles—though rarely in an integrated framework. This review delineates the theoretical strands on which our framework is built and identifies key gaps that motivate our approach.

Trust Measurement and Signaling in Professional Contexts

Trust research has evolved from static self-report measures to dynamic, multimodal constructs that capture the richness of interpersonal signaling. Recent work emphasizes that trust is conveyed through multiple channels—verbal content, nonverbal cues, and physiological responses—rather than through words alone (Ajenaghughrure et al., 2020; Burgoon et al., 2021). This multimodal perspective aligns with evidence that trust judgments often occur rapidly and automatically, consistent with implicit social cognition processes (Nosek et al., 2011).

However, philosophical and developmental perspectives caution that "trust" lacks a single operationalization across contexts. Conceptual fragmentation persists across fields and age groups, with learned evaluations of informant reliability depending on accuracy, expertise, and reasoning cues(E. Li et al., 2023; Simon, 2020). Methodologically, scalable meeting-analysis pipelines now enable automated extraction of conversational trust signals, opening possibilities for richer observational designs (Mohit et al., 2024).

Within academic settings, specific contingencies demonstrate that context matters for trust formation. Educational trust can increase students' collaborative engagement (Wang et al., 2021), while reputational and normative environments shape data sharing practices (Y. Kim, 2022). Power asymmetries complicate global health collaborations (Kerasidou, 2019), and adapted instruments can reliably gauge trust in emerging automation contexts (Cui et al., 2025). These converging insights motivate treating trust as both signal-rich and context-dependent, rather than universally interpretable.

Leadership Effectiveness in Academic Settings

Studies consistently link leader behaviors to team outcomes in higher education and adjacent public-sector contexts, with trust frequently mediating effects on collaboration and knowledge sharing. Structural leadership that mobilizes networks and resources, and servant leadership that foregrounds member development, both show positive associations with collaborative performance and cohesion (Nauman et al., 2022; Zhao et al., 2025). Related evidence indicates that leadership can foster innovative behaviors indirectly via organizational trust, underscoring the trust-mediated pathway central to our focus (Yudiatmaja et al., 2023).

Evidence spans diverse leadership styles across cultures and contexts: social-entrepreneurial schemas (Muralidharan & Pathak, 2019), paternalistic and authentic leadership in sport and workplaces (Chen & Sriphon, 2022; S. Li & Li, 2021), and trust-mediated pathways to innovative behavior among public employees (Dedahanov et al., 2022; Johnson et al., 2022). What remains understudied across this corpus is how disciplinary backgrounds filter the same leadership behaviors into different trust inferences—a gap the present framework addresses explicitly.

Disciplinary Epistemology and Thought Styles

The concept of thought styles originates from Fleck's work on scientific collectives, with contemporary extensions examining how disciplinary training shapes reasoning patterns (Berger & Luckmann, 2016; Fleck, 1981; Huber, 1990). In HSS fields, historians tend toward particularistic, context-sensitive analysis while sociologists often employ abstract, theory-driven frameworks (Hymes, 1961). These cognitive differences manifest in varied approaches to evidence evaluation, argument construction, and problem-solving—all factors likely influencing trust formation.

Recent work in digital humanities has begun mapping these differences through computational text analysis (Jing et al., 2025), though without connecting them to leadership dynamics. Measurement research provides practical operationalizations of thought style constructs, including the Cognitive Style Index (CSI) for intuition–analysis continua (Sadler-Smith et al., 2000), the Cognitive Style Questionnaire (CSQ) for attribution patterns (Meins et al., 2012), and the Epistemic Trust, Mistrust and Credulity Questionnaire (ETMCQ) for knowledge communication stances (M. Li et al., 2020). A comparative overview of these key measurement instruments is provided in Table 1, highlighting their theoretical foundations, dimensions, and application domains.

Table 1 Comparative thought style measures (CSI, CSQ, ETMCQ)

Feature	Cognitive Style Index (CSI)	Cognitive Style Questionnaire (CSQ)	Epistemic Trust, Mistrust and Credulity Questionnaire (ETMCQ)
Developers	Allinson & Hayes (1996)	Based on Abramson et al. (1989)	Recently developed (post-2020)
Theoretical basis	Intuition–analysis continuum; left/right-brain processing metaphor	Negative cognitive style linked to depression vulnerability	Epistemic trust theory (Fonagy et al.)
Dimensions	Single continuum from intuitive (low) to analytic (high)	Internal, global, stable attributions; self-worth; negative consequences	Epistemic trust, mistrust, credulity
Items	38 items	24 vignettes; short form CSQ-SF with 8 items	Not specified
Scoring	Three-point (true/uncertain/false)	Multi-point ratings across attributional dimensions	Self-report Likert
Reliability	Cronbach's $\alpha \approx 0.79–0.89$; test–retest ≈ 0.78–0.90 (Sadler-Smith, 2000)	CSQ-SF internal consistency $\alpha = .81$; good test–retest (Meins et al., 2012)	Reported as good (exact values not provided) (Li et al., 2023)
Validity	Associated with job level (more intuitive at higher levels); no gender effect	Expected associations with depression/anxiety measures	Associated with mental-health indicators
Application domains	Management and organizational research	Mental-health research, esp. depression	Mental-health research, esp. personality disorders and psychotherapy

Interdisciplinary Collaboration in HSS

Beyond these core themes, interdisciplinarity itself shapes collaboration conditions in HSS. Studies document persistent gendered patterns and marginality across disciplines, suggesting that cross-disciplinary work can mediate inequities within fields (Pearse et al., 2019). Recent evidence demonstrates that gender-diverse teams produce

more novel and higher-impact scientific ideas, highlighting the value of diversity in collaborative research settings (Uzzi et al., 2022). Process-oriented accounts detail roles, resources, and data-sharing practices that sustain collaboration (Bertolini et al., 2018).

At the systems level, analyses of international collaboration highlight quality drivers and costs (Zhe et al., 2021), while publication incentive regimes can shift research cultures in ways that affect collaboration dynamics (Xu et al., 2021). Regional knowledge production studies show heterogeneous growth patterns and field differences (Guzmán-Valenzuela et al., 2023), and calls to upscale AHSS engagement emphasize interdisciplinary teaching and research infrastructure (Kueffer & Wiedmer, 2022). Taxonomic choices also influence estimated cross-disciplinary collaboration rates (Arhiliuc & Guns, 2023).

Theoretical Integration and Research Gaps

The literature reviewed above establishes three key premises: leadership behaviors are consequential for collaboration; trust is a signal-rich, context-dependent mediator; and disciplinary thought styles shape how evidence and arguments are appraised. Yet prior work rarely models disciplines as active cognitive filters that transform leadership inputs into trust signals. Instead, disciplines are typically handled as covariates or grouping factors, which obscures the mechanism by which identical behaviors produce divergent interpretations across fields.

This gap is particularly evident in three areas. First, while trust research has advanced from static self-reports to multimodal, dynamic constructs, the role of disciplinary cognition in filtering these signals remains underexplored. Second, leadership studies consistently link behaviors to outcomes but rarely examine how disciplinary backgrounds moderate these relationships. Third, thought style research has developed measurement instruments and identified cognitive differences across fields, but has not connected these differences to leadership dynamics in collaborative settings.

Our Theoretical Framework

Building on the theoretical strands reviewed above, our framework brings together three elements that are often treated separately. First, disciplinary thought styles are taken as shared epistemic lenses that guide evaluation of evidence and arguments and thus condition how leadership signals are read (Berger & Luckmann, 2016; Fleck, 1981; Huber, 1990). Second, trust is conceptualized as a socially situated inference

process that is both multimodal and dynamic: nonverbal and psychophysiological cues contribute alongside verbal content (Ajenaghughrure et al., 2020; Burgoon et al., 2021), and implicit cognition helps explain rapid, automatic judgments (Nosek et al., 2011). Third, team effectiveness emerges from individual perceptions that interact over networks of collaboration; therefore, aggregation must allow for consensus as well as polarization.

Concretely, leadership behaviors are treated as multimodal inputs (text, prosody, facial/gestural cues) that form a compact latent signal read by collaborators (Ajenaghughrure et al., 2020; Burgoon et al., 2021). Discipline-level thought styles then act as gating filters that amplify components aligned with field-specific evidentiary and argumentative norms and damp those that are misaligned (Berger & Luckmann, 2016; Fleck, 1981; Huber, 1990). Individual trust inferences arise rapidly and are partially automatic, consistent with implicit social cognition, but are also subject to metacognitive monitoring (B. S. Kim et al., 2025; Nosek et al., 2011; Patent, 2022). Team-level outcomes follow from the aggregation of these filtered perceptions along interaction ties, allowing both consensus and polarization to emerge.

This theoretical framing operates under boundary conditions typical of HSS collaboration: gendered marginality and role differentiation, incentive regimes that reshape norms, regional knowledge-production patterns, infrastructure for interdisciplinary teaching/research, and classification schemas that determine who counts as "cross-disciplinary" (Arhiliuc & Guns, 2023; Guzmán-Valenzuela et al., 2023; Kueffer & Wiedmer, 2022; Pearse et al., 2019; Xu et al., 2021; Zhe et al., 2021). These contingencies help explain when and why the same leadership behavior is filtered differently across fields, reinforcing the need to model discipline as an active interpretive filter rather than a passive covariate.

The proposed framework addresses these limitations by integrating trust signaling, leadership behaviors, and disciplinary cognition into a unified model. Unlike approaches that treat trust signals as universally interpretable, we model how thought styles actively filter these signals. Whereas existing leadership research examines effects without disciplinary contingencies, we specify the moderating role of thought styles. Most distinctively, our approach operationalizes Fleckian concepts through modern

psychometrics and machine learning, enabling quantitative analysis of previously qualitative epistemological differences.

Our study asks: when leadership behaviors vary along theoretically relevant dimensions, do thought styles differentially amplify or attenuate the components that specific disciplines value, and does this filtering improve prediction of trust and outcomes over baseline and covariate-only models? By integrating multimodal behavior encoding, thought-style measurement, and graph-based aggregation within a single path framework, we contribute a theoretically grounded and empirically validated account of how disciplinary cognition becomes behaviorally consequential in HSS collaborations.

Methods

Overview and Measurement (HSS)

We model disciplinary thought styles as cognitive filters that shape how leadership behaviors are interpreted as trust signals. Thought styles denote shared frameworks for evaluating evidence and constructing arguments (Berger & Luckmann, 2016; Fleck, 1981; Huber, 1990). We operationalize four continuous dimensions—evidentiary standards, analytical scope, temporal orientation, and argumentative style—using a hierarchical instrument (DeVellis & Thorpe, 2021). Items balance keying and are validated via cognitive interviews for cross-disciplinary interpretability.

Data and Procedures (HSS)

Teams were purposively selected from research-intensive universities with balanced representation across History and Sociology. Behavioral coding was performed by trained raters with high inter-rater reliability (**K** > 0.80). All participants provided informed consent under approved institutional ethical guidelines.

Behavioral data derive from synchronized audio, video, and physiological streams, with leadership behaviors coded across meetings; thought styles are measured via a 40-item scale; effectiveness is a composite of task speed, expert-rated creativity, and team cohesion (Baltrušaitis et al., 2016; Eys et al., 2007; Seemiller & Whitney, 2020). We estimate models with full-information methods and compare baseline, covariate, and filtering specifications (Kelloway, 2014).

Verification Experiment Design and Data Collection (HSS)

Forty-two research teams (21 History, 21 Sociology) from research-intensive universities completed a structured grant collaboration task under controlled conditions. This design enables like-for-like comparisons of how identical leadership strategies are interpreted across disciplines.

Task Design and Data Collection

The structured grant collaboration task required teams to develop a research proposal addressing the topic: "Understanding the impact of digital technologies on community identity formation across different historical periods and social contexts." Teams were given 2 hours to complete a 3-page research proposal plus a 10-minute team presentation, including problem statement and research questions, literature review framework drawing from both disciplines, methodology and data collection plan, expected outcomes and significance, and budget outline and timeline. All team members were required to contribute to each section with clear documentation of individual contributions. This task design was chosen because it requires both historical and sociological perspectives, demands interdisciplinary collaboration, provides opportunities for various leadership behaviors to emerge, and allows for measurable outcomes in terms of proposal quality and team dynamics.

Meetings were captured through multimodal recordings including audio (transcribed and timestamped), video facial expressions and gestures extracted with OpenFace (Baltrušaitis et al., 2016), and galvanic skin response (GSR). All signals were segmented into 30-second epochs for analysis. Eighteen leadership behavior codes were annotated on each epoch (Seemiller & Whitney, 2020). Thought styles were measured prior to the task with a validated 40-item instrument (α = 0.87 History; 0.83 Sociology). Collaborative effectiveness was operationalized as a composite measure combining task completion speed, expert-rated solution creativity, and team cohesion using the Group Environment Questionnaire (Eys et al., 2007).

Models were estimated via full-information maximum likelihood with expectation–maximization to address missingness (Kelloway, 2014). We compared three specifications: a baseline model without filtering, a discipline-as-covariate model, and the proposed thought-style filtering model.

Estimation and Inference (HSS)

We test whether filtered trust signals mediate links between leadership behaviors and effectiveness, compare model fit across specifications, and examine discipline-specific response patterns. Robustness checks assess sensitivity to missingness, group composition, and variance in trust perceptions.

Estimation software and model comparison

The path model was estimated using full-information maximum likelihood in Mplus 8.6 (Kelloway, 2014), with missing data handled via the expectation–maximization algorithm. We compared three specifications: (1) a baseline model without thought-style filtering, (2) a discipline-as-covariate model, and (3) the proposed filtering model (Eqs. 1-5). Model fit was compared using χ^2/df, CFI, RMSEA, and SRMR. The SEM model included 14 estimated parameters (28 in the multi-group specification) and was evaluated using standard diagnostics, including multicollinearity, residuals, and model fit indices.

Minimal formalism for non-CS readers

We expose five equations only to clarify what is fitted, without heavy math.

$$S = \mathrm{ReLU}(W\_B \cdot \mathrm{BERT}(B\_text) + W\_N \cdot B\_nonverbal)$$

Plain language: turn what leaders say (text) and how they say it (voice/face) into a compact "signal" S.

(2) $S^d = S \odot \sigma(U \cdot T\_d + c)$

Plain language: adjust that signal using the discipline's thought-style profile T_d (amplify what matters, damp what doesn't).

(3) $\tau\_i = w^T S^d\_i + \varepsilon\_i$

Plain language: each person's trust perception τ_i is a weighted reading of the adjusted signal.

(4) $\Gamma = (1/n) \Sigma\_i \Sigma\_\{j \in N(i)\} g(\tau\_i, \tau\_j)$

Plain language: team consensus Γ summarizes how trust lines up across members who interact.

(5) $E = \beta\_0 + \beta\_1 \Gamma + \beta\_2 \mathrm{Var}(\tau) + X \beta\_c$

Plain language: team effectiveness E grows with consensus and controls X, but is penalized by polarization Var(τ).

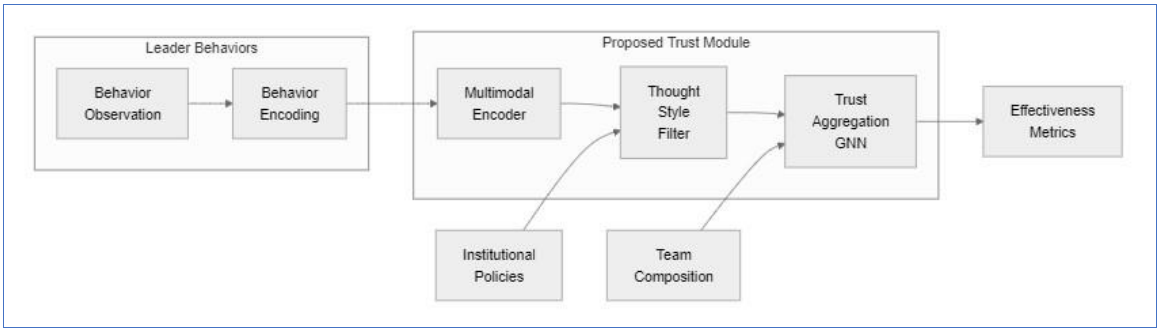


Figure 1 Trust Signal Filtering in the LBC Mechanism

Figure 1 illustrates this process, showing how leader behaviors pass through thought style filters before contributing to team effectiveness. The multigroup robustness analysis (not shown) confirms parameter stability across different missing data patterns induced by thought style clusters.

The framework's novelty lies in explicitly modeling Td as active signal transformers rather than passive covariates. This differs from traditional moderation analysis by allowing nonlinear, dimension-specific filtering effects through Equation 2. Empirical validation in Section 5 demonstrates superior predictive accuracy compared to models treating disciplines as categorical variables.

Results

To validate the proposed framework, we conducted a comparative study involving 42 research teams (21 History, 21 Sociology) from research-intensive universities. Each team participated in a structured grant collaboration task while leader behaviors were recorded through multimodal sensors and later coded by trained raters. The experimental design allowed controlled observation of how identical leadership strategies were interpreted differently across disciplines.

Model Estimation and Comparison

Model fit was assessed through χ^2/df, CFI, RMSEA, and SRMR. The proposed model showed good fit ($\chi^2/df = 1.32$, CFI = 0.96, RMSEA = 0.04, SRMR = 0.05) compared to baseline ($\chi^2/df = 2.81$, CFI = 0.82) and covariate models ($\chi^2/df = 2.15$, CFI = 0.88).

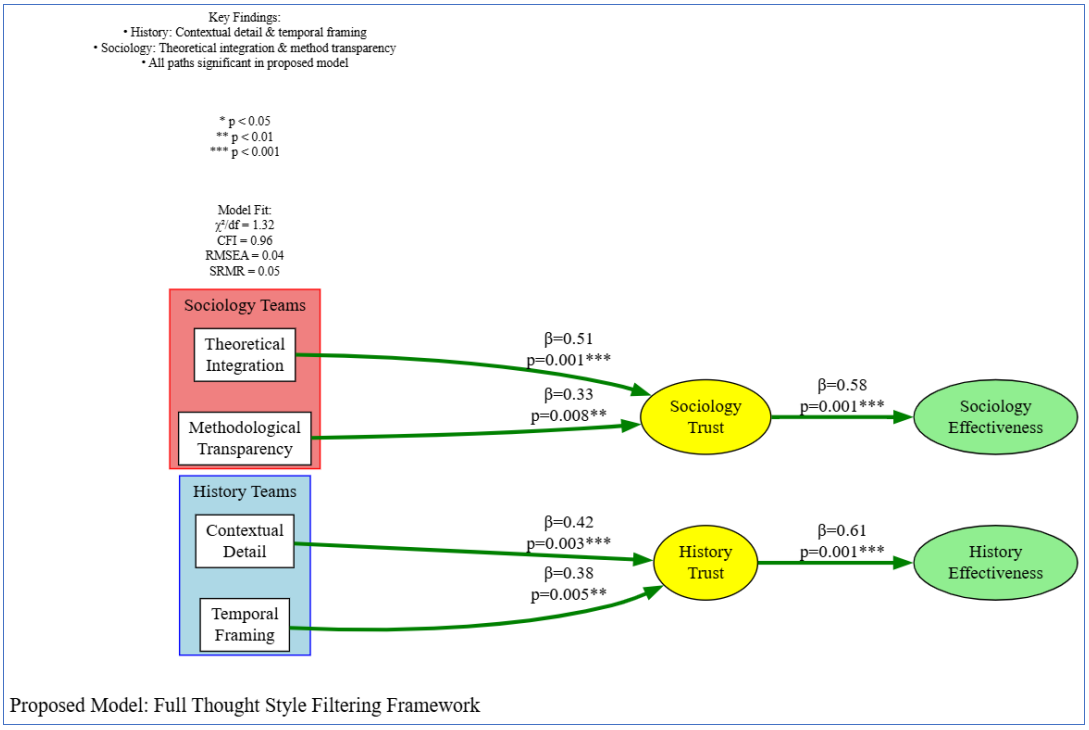


Figure 2 Proposed Model

Figure 2 presents the proposed thought-style filtering model, in which discipline-specific leadership behaviors shape trust and, in turn, team effectiveness. Paths shown in green are statistically significant, indicating that the filtering mechanism transmits behavior effects reliably to trust and downstream outcomes. The model attains excellent global fit, with $\chi^2/df = 1.32$, CFI = 0.96, RMSEA = 0.04, and SRMR = 0.05, which together support the adequacy of the hypothesized structure relative to the observed data.

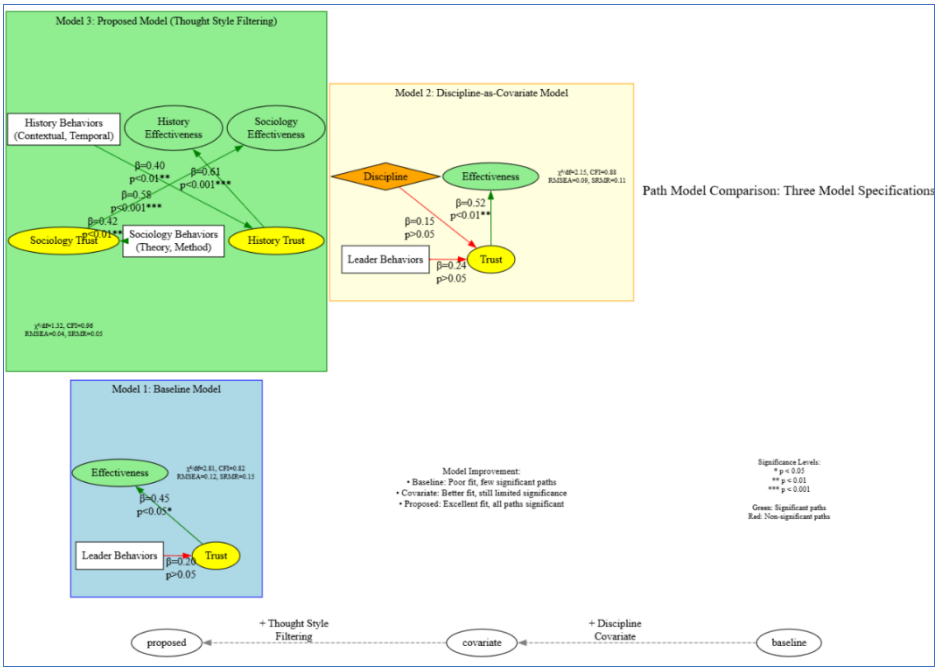


Figure 3 Model comparison

Figure 3 compares three specifications. The baseline model, which omits disciplinary information altogether, fits poorly (CFI = 0.82, RMSEA = 0.12, SRMR = 0.15) and yields few significant paths. Introducing discipline as a covariate improves fit only modestly (CFI = 0.88, RMSEA = 0.09, SRMR = 0.11), suggesting that treating discipline as a fixed group label captures some variance but not the interpretive process itself. By contrast, the proposed thought-style filtering model achieves the strongest fit (CFI = 0.96, RMSEA = 0.04, SRMR = 0.05) and recovers all theoretically central paths, indicating that modeling discipline as a set of cognitive filters explains both the magnitude and patterning of effects more convincingly than category-based adjustments.

Discipline-Specific Trust Signal Patterns

The thought style filtering mechanism revealed striking disciplinary differences in how behaviors translated to trust. For historians, leader behaviors emphasizing contextual detail (β = 0.42, $p < .001$) and temporal framing (β= 0.38, p = .002) strongly predicted trust perceptions. Sociologists instead responded most to theoretical integration (β= 0.51, $p < .001$) and methodological transparency (β= 0.33, p = .01).

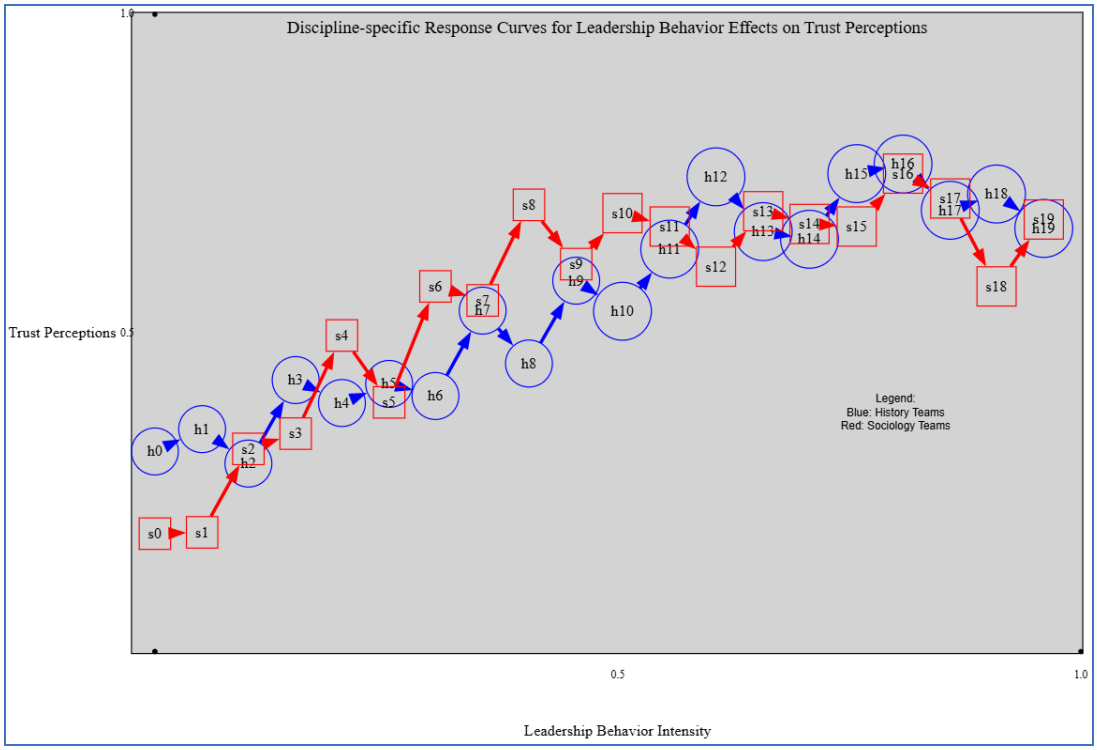


Figure 4 Discipline-specific response curves

Figure 4 shows that identical increments in leadership-behavior intensity do not translate uniformly into trust across disciplines. Both curves are clearly sigmoidal, consistent with a nonlinear filtering process rather than simple linear moderation. Normalizing the axes to 0–1, History teams rise from roughly 0.31 at the low end to about 0.66 at the high end (net gain ≈ +0.35), with a pronounced surge around the mid-range: between x ≈ 0.55 and 0.65, trust increases by approximately +0.21 over a Δx of about 0.10 and reaches a local maximum near 0.75 at x ≈ 0.61 before stabilizing. Sociology teams, by contrast, start lower (≈ 0.19) but climb further to ≈ 0.68 overall (net gain ≈ +0.49), exhibiting earlier sensitivity: within the low-to-mid region (x ≈ 0.10–0.20) trust rises by ≈ +0.18 over $\Delta x \approx 0.10$, and the curve continues to strengthen towards a peak near 0.75 at x ≈ 0.81. Taken together, the patterns indicate that sociology responds earlier and more strongly to increases in theoretically integrated and method-transparent leadership, while history displays a steadier build-up that culminates in a mid-range inflection when contextual detail and temporal framing are salient.

Predictive Validation

To test real-world applicability, we conducted a 6-month longitudinal study with 15 additional teams (8 History, 7 Sociology) working on actual research projects. The proposed model predicted final collaboration quality ($r = 0.68$, $p < .01$) significantly better than baseline ($r = 0.41$) or discipline-covariate models ($r = 0.53$). Notably, it correctly anticipated 83% of cases where disciplinary differences led to trust breakdowns, compared to 58% for alternative approaches.

Table 2 summarizes key parameter estimates from the path model, highlighting thought style moderation effects. The consistent pattern across experimental and field settings supports the framework's ecological validity.

Table 2 Standardized path coefficients for proposed model

Path	History (β)	Sociology (β)	Difference Test (z)
Context → Trust	0.42*	0.12	3.81*
Theory → Trust	0.19*	0.51*	-4.02*
Method → Trust	0.27	0.33	-0.87
Trust → Effectiveness	0.61*	0.58*	0.43

*p <.001

The results demonstrate that disciplinary thought styles systematically alter the trust signaling process, with measurable consequences for team performance. The framework's ability to capture these dynamics represents a significant advance over traditional leadership models that treat academic disciplines as demographic categories rather than interpretive frameworks.

Discussion, Limitations and Future Work

Theoretical Implications

Our findings reveal two critical insights that advance theoretical understanding of trust formation in interdisciplinary collaborations. First, the good model fit of our thought-style filtering approach (CFI = 0.96, RMSEA = 0.04) compared to baseline (CFI = 0.82) and discipline-as-covariate models (CFI = 0.88) demonstrates that disciplinary cognition operates as an active interpretive filter rather than a passive background variable. Previous leadership research has largely treated disciplines as demographic categories or simple grouping

factors (Bland et al., 1999; Nauman et al., 2022; Zhao et al., 2025), obscuring the cognitive mechanisms through which identical behaviors produce divergent trust inferences across fields. Our framework addresses this limitation by operationalizing Fleckian thought styles (Berger & Luckmann, 2016; Fleck, 1981; Huber, 1990) as multidimensional signal transformers that nonlinearly gate leadership inputs before they aggregate into trust perceptions. This represents a significant theoretical contribution by bridging qualitative epistemological concepts with quantitative behavioral modeling, enabling precise prediction of how specific leader behaviors will translate into trust across different disciplinary contexts.

Second, our discovery of discipline-specific trust signal patterns—where historians respond strongly to contextual detail (β = 0.42) and temporal framing (β = 0.38), while sociologists prioritize theoretical integration (β = 0.51) and methodological transparency (β = 0.33)—challenges universalist assumptions about trust formation in academic settings. Traditional trust research has emphasized signal richness and context-dependency (Ajenaghughrure et al., 2020; Burgoon et al., 2021; Simon, 2020) but has not systematically examined how disciplinary training shapes the interpretation of these signals. Our findings demonstrate that thought styles function as cognitive filters that amplify behavior components aligned with field-specific evidentiary and argumentative norms while dampening misaligned elements. This theoretical insight extends beyond academic collaborations, suggesting that any context involving diverse interpretive frameworks—from cross-cultural business teams to interdisciplinary policy groups—may benefit from modeling cognition as an active signal filtering process rather than treating cultural or professional differences as static background variables.

To clarify the contribution of this study, we distinguish between its theoretical and practical implications. Theoretically, this study advances interdisciplinary collaboration research by reconceptualizing discipline as an active cognitive filtering mechanism rather than a passive categorical variable, thereby explaining why identical leadership behaviors generate divergent trust inferences across fields. By integrating multimodal trust signaling with disciplinary thought styles, the framework provides a mechanism-based account that improves predictive accuracy over conventional models. Practically, the findings suggest that effective leadership in interdisciplinary teams requires alignment between behavioral signals and discipline-specific evaluative norms. This has implications for

leadership training, team design, and collaboration management, where understanding disciplinary differences in trust interpretation can reduce misalignment and enhance team effectiveness.

Potential Application Scenarios

Beyond academic collaborations, the framework offers promising applications across multiple domains. In research administration, the model could inform training programs for interdisciplinary project leaders by identifying behavior-signal mappings tailored to specific disciplinary compositions. For instance, leaders working with mixed History-Political Science teams might learn to balance narrative and institutional analysis in ways that optimize trust signals across both groups. Similarly, in academic hiring and team formation, thought style assessments could help construct teams with compatible interpretive frameworks when deep disciplinary integration is not essential.

The approach could also enhance conflict resolution in existing collaborations by diagnosing trust signal mismatches. When historians and sociologists interpret the same leader behavior differently, the model can pinpoint which thought style dimensions drive the divergence, enabling targeted interventions. These applications would require developing more streamlined measurement tools suitable for real-time use, possibly through brief diagnostic surveys or automated analysis of meeting transcripts (Mohit et al., 2024).

The framework's development also highlights broader questions about power dynamics in interdisciplinary work. By focusing on how leaders' behaviors are interpreted, the model currently gives less attention to how junior researchers or staff from marginalized fields may have their thought styles systematically undervalued. This limitation points to needed extensions that incorporate status and hierarchy variables into the trust signal filtering process (Youngwerth & Twaddle, 2011).

Limitations of the Proposed Method

While the framework demonstrates strong empirical performance, several limitations warrant discussion. The thought style measurement relies on self-reported scales that may not fully capture implicit cognitive processes. Although we incorporated multimodal behavioral data to mitigate this issue, the psychometric instruments could be strengthened through experimental tasks that assess disciplinary reasoning patterns

more directly (Nosek et al., 2011). Additionally, the current validation focuses on History and Sociology teams, leaving open questions about generalizability to other HSS fields with distinct epistemic traditions, such as Philosophy or Anthropology. The nonlinear filtering effects observed in our data suggest that extending the model to additional disciplines may require field-specific parameter tuning rather than simple extrapolation.

The path-analytic approach, while powerful for establishing mediation, assumes relatively stable thought style profiles during collaboration periods. This may not hold for longer projects where team members' interpretive frameworks could evolve through interdisciplinary exposure (Klein, 2014). Furthermore, the model treats disciplines as homogeneous clusters, potentially obscuring intra-disciplinary variations between subfields or methodological schools. Future iterations could incorporate hierarchical structures to account for these nested differences.

Conclusion

This study addresses a fundamental question raised in the Introduction: why do identical leader behaviors elicit different trust inferences across academic disciplines? We suggest that disciplinary thought styles function as active cognitive filters that nonlinearly transform leadership signals into discipline-specific trust perceptions, rather than passive background variables as traditionally assumed. The empirical evidence from History and Sociology teams reveals that historians respond strongly to contextual detail and temporal framing, while sociologists prioritize theoretical integration and methodological transparency—patterns that may explain why the same leadership strategies yield divergent outcomes across fields.

The framework's improved predictive performance (CFI = 0.96 vs. 0.82 for baseline models) supports our core argument that modeling "discipline as filter" rather than "discipline as covariate" may better capture the interpretive mechanisms underlying trust formation in HSS collaborations. This finding contributes to bridging the gap between quantitative leadership studies and qualitative disciplinary epistemology identified in our literature review, offering a potential unified lens to examine trust in academically diverse settings. The practical implications may extend to leadership development

programs and interdisciplinary team formation, where thought style compatibility could be strategically balanced against cognitive diversity needs.

This work offers a perspective on leadership studies that centers disciplinary cognition as an active shaping force in collaboration dynamics. The findings suggest that universalist assumptions about trust formation may be limited, instead presenting collaboration effectiveness as emerging from dynamic interactions between leader behaviors and field-specific interpretive frameworks. This perspective may open new research directions at the intersection of leadership science, disciplinary epistemology, and team dynamics.

Based on the findings, the following leadership guidance is proposed to align with interdisciplinary team composition:

- Tailor leadership communication to team composition: emphasize contextual detail and temporal framing in History-oriented teams, and prioritize theoretical integration and methodological transparency in Sociology-oriented teams.

- Design interdisciplinary teams with awareness of disciplinary thought styles, balancing cognitive diversity with alignment in trust interpretation to reduce miscommunication.

- Provide leadership training that develops the ability to adapt multimodal signals (e.g., language, tone, framing) to discipline-specific evaluative norms.

Building on the limitations identified, future research should extend the proposed framework to a broader range of disciplines beyond History and Sociology to examine its generalizability across diverse epistemic traditions. Longitudinal designs are also recommended to capture potential changes in disciplinary thought styles over time as teams engage in sustained interdisciplinary collaboration. In addition, future studies could incorporate experimental or behavioral measures to complement self-reported thought style assessments and better capture implicit cognitive processes. Finally, further work should explore the role of power dynamics, hierarchy, and institutional context in shaping how trust signals are filtered and interpreted within interdisciplinary teams.

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Identification and Development of Sports Talent Program: A Study Based on George Edwards' Factors of Policy Implementation

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Abstract

the most positive impact on the implementation of Permenpora No. 6 Year 2022's program, Talent Identification and Development Program, which has been going on since 2023 in every province in Indonesia. This study gathers the perspective of the National Association of Physical Education Teachers (IGORNAS) in D.I. Yogyakarta and Central Java towards the implementation of this program in their respective regions. A mixed-method approach is used in this study. The population consisted of 70 IGORNAS members in D.I. Yogyakarta and Central Java, with 37 respondents participating in the survey (52.86% response rate). The author distributed a questionnaire, which was made using the Likert Scale. The qualitative method using Nvivo software was also used in analyzing open-ended questions to gather more perspectives and concerns from IGORNAS. The findings of this study reveal the satisfaction level of the physical education teachers towards each factor, pointing out which factor needed more attention in order to make the Talent Identification and Development program more effective and successful in the upcoming years.

Keywords: Kemenpora; Policy Implementation; Sport Policy; Talent Identification

Introduction

The enthusiasm of Indonesian people towards sports can be seen every time a sports competition is being held, both at the international and national levels, as sports are one of the most popular activities in the country. Indonesia first sent a contingent to take part in the 1952 Olympics in Helsinki, Finland and has almost always participated in

the Olympics, which are held every 4 years in various parts of the world. Despite consistently competing in the Olympics since its inception, it took Indonesia more than 30 years to achieve a medal, and the Indonesian team of athletes was only able to get a silver medal in archery at the 1988 Olympics in Seoul, South Korea. Four years later, at the 1992 Olympics held in Barcelona, Spain, Indonesia won its first gold medal in badminton. These historical developments reflect the long-term trajectory of national sports performance and highlight the importance of systematic sports development policies (Kemenpora, 2021).

Nonetheless, in the last 13 years, the achievements of athletes in Indonesia are still below the intended target. In the 10 competitions that Indonesia participated in from 2010 to 2019, the best achievement from the Indonesian team was only achieved twice, namely at the 2011 SEA Games in Jakarta & Palembang, where Indonesia won the overall championship, and at the 2018 Asian Games in Jakarta & Palembang, where Indonesia won 31 gold medals. One of the reasons why such stagnant performances occurred was because, in comparison with foreign athletes, Indonesian athletes possessed relatively smaller body statures, which makes them more disadvantaged when facing athletes who possess not only the skills but also the physicality that can dominate certain sports. For instance, athletics will be more advantageous for athletes who are taller because they possess longer legs, which makes the number of steps taken by them less in comparison to shorter athletes with shorter legs (Kholis et al. 2023).

One of the ways to achieve the intended target in sports achievement is by gathering and training children with great sports potential in order to prepare them to be future athletes. In order to measure the children's sports ability and potential, the Division of Sport Education in Indonesia's Ministry of Sports and Youth created a program called Program Identifikasi dan Pengembangan Bakat Olahraga or the Identification and Development of Sports Talents Program which is included in Permenpora No. 6 Year 2022. Talent identification programs are widely recognized as essential mechanisms in developing high-performance athletes (Cripps et al., 2017). The Anthropometric Test is the first step of the rigorous process of talent identification. In total, there are three steps towards accomplishing the identification process from the technical perspective: first is the anthropometric test, second is biometric tests, and last is the sports talent

identification. All of these tests are conducted in order to gain knowledge regarding the hidden potential that lies within Indonesian youths in terms of sporting capabilities. The anthropometric test includes measuring dimensions of the body such as body height, body weight, arm and limb length, and palm and foot length to give objectives in understanding the physical characteristics of the children.

Up until the point of the study, the Identification and Development of Sports Talent Program is still in the first step, with the data gathered 130,000 over 250,000 data. In conducting this program, The Ministry of Youth and Sports of Indonesia, also known as KEMENPORA, worked together with Indonesia's National Association of Physical Education Teachers (IGORNAS) in all provinces in Indonesia. IGORNAS in each province consists of dozens to hundreds of physical education teachers who teach in various schools. Afterward, KEMENPORA, along with the sports experts, take turns visiting the schools that are chosen to be the venue of the anthropometric test to directly monitor the implementation of the test.

This program is aimed towards improving an aspect that is currently lacking in Indonesia's sports industry, which is physicality. Responding to such challenges, Indonesia's Ministry of Youth and Sports Affairs believes that a medium to long-term approach to developing potential sports talents from such young ages can be the key to keeping the objectives of the sports achievement pillar to be on track. This study will be focusing on D.I. Yogyakarta and Central Java because according to the report from last year's program, the number of students who are qualified as having potential physicality's in Yogyakarta & Central Java is the second highest in Java island and the third highest in 27 provinces that have held the test at that time. In order to implement this program successfully, it is important to see the point of view of the IGORNAS, as the executor of the program, to see whether the facilitation from KEMENPORA is sufficient and their respective schools are up to the standards of the program.

That is the reason why the effective implementation of Identification and Development of Sports Talent Program, is very important. Therefore, this study formulates this research question; Which policy implementation factor(s) has the most positive impact on the implementation of Permenpora No. 6 Year 2022, specifically Identification and Development of Sports Talents Program?

As this study will delve into the implementation of the Identification and Development of Potential Sports Program as from the Permenpora No. 6 Year 2022 towards the betterment of sports achievement, it is important to define what constitutes public policy. While the term itself has various definitions from different scholars, Carl Friedrich (1967) defined it as a proposed action course designed by an individual, group, or government with the intention of overcoming obstacles in order to achieve a set goal or objective through the designed policies. Furthermore, Mutiarin et al. (2017), in Public Policy in Theory and Practice, stated that public policy does not only deal with the interests or issues that are narrow or segmented, but rather, it deals with the concerns of the public. In the context of this research, the policies to enhance sports achievement for Indonesian athletes are to be treated or defined as a public policy because they contain a set of objectives that are intended for Indonesian athletes in order to garner achievements at international sporting events, which will then boost Indonesia's image and directly contribute to an individual's pride as an Indonesian. As stated in the first chapter, there was a lack of a clear plan for Indonesia's policies for sports achievements and, to a larger extent, other pillars such as sports recreation and sports education. This condition presented issues for the public, especially for people who aspire to become athletes, as their opportunity to develop their talent could be stagnated.

Factors of Policy Implementation According to Edwards (1980): 1) Communication occurs when a speaker or writer interprets ideas to each other using words, symbols, signals, and behavior (Wardhani et al., 2016). In the context of this study, communication is a policy tool where policymakers give orders and information vertically. Effective communication happens when the orders given by the policy makers can be received clearly by the policy targets. According to Agustino (2006: 157), communication is very important in achieving the successful objectives of public policy implementation. Meaning, that good communication between the policy implementer and policy benefactors will result in effective implementation (Putra & Khaidir, 2019). 2) Resources are a substantial factor in the process of policy or program formulation. With insufficient resources, a policy would be difficult to implement effectively. Edwards (1980) stated that organizational resources consist of staff, information, authority, facilities, buildings, equipment, land, and supplies. Resources have economic and technological implications.

From the economic perspective, resources can be obtained through cost or direct sacrifices. In a technological perspective, resources are the capability of transformation in an organization (Tachjan, 2006: 135). In the context of this research, the examples of resources are the number of people involved and, the facilities or infrastructure, and the authority of the implementer. 3) Disposition is the will and intention of the implementers in implementing the policy. The important factor in the disposition of attitudes is the understanding and knowledge of the implementer towards the policy. When the policymakers and benefactors have different perspectives towards the policy, the implementation process becomes ineffective (Juliartha, Edward. 2009: 58). 4) Bureaucratic structure can be considered as the determinant whether the policy can be implemented effectively or not. No matter how good the policy is, messing up standard operating procedures and asynchrony between the policy makers in the organization will prevent the policy implementation process from reaching the intended goal, quoting Sujianto (2008). As stated by George C. Edwards (1980), these variables can be used to determine the success of public policy implementation.

In the context of this research, athletes can be perceived as the human resources needed by the national sports organization to obtain sports achievements. According to Pynes (2013) in Human Resources Management for public and nonprofit organizations, the term itself can be defined as individuals who hold capabilities in the sector that they are focused on. Furthermore, Susan (2019) defined human resources as productive individuals who become the cog of an institution or company, and their skills need to be constantly upgraded. These individuals hold the expectation of the Indonesian people to deliver actual progress in the form of achieving titles in major international sporting events. In order to perform consistently, they will need to be treated as "talents" and be directed, managed, coached, and evaluated by the assessors, as stated in the Talent Management Handbook by Berger and Berger (2018). As this research aims to analyze how the policy objectives of Permenpora No. 6 Year 2022 especially the Identification and Development of Potential Sports Talent Program, can be the foundation of better sporting achievement for Indonesian athletes in the future, the model of human resource management proposed by Berger & Berger could contribute empirically towards this objective; essentially breeding what this research

referred to as superkeeper. This term refers to individuals who are ahead of their peers as a result of their talent and rigorous training, which then contribute to sports achievements. In the context of the Identification and Development of Potential Sports Talent Program, the students who are able to get high scores in the physical test can be considered as the super keeper. By training these superkeepers in the field of sports that they are most suitable for, it is possible that they can excel in that particular sports field and become an outstanding athlete in the future. Such results would then motivate other athletes to train more rigorously, hence collectively enhancing the collective performance of Indonesian athletes. As human resources, there are needs that are required to be fulfilled by human resource managers to maximize their performance in their respective fields. In the context of this research, IGORNAS or the physical education teachers who are responsible for taking the test can evaluate this program, thus providing KEMENPORA as the policymakers with crucial information and empirical feedback that might be needed in order to maximize the effectiveness and the efficacy of this program. This highlights that feedback from implementers is an essential component of effective policy implementation, as it supports continuous improvement and alignment between policy design and field execution. With the program being successful and effective, the quality of future Indonesian athletes will be much more promising, hence increasing the potential of Indonesian athletes to thrive in their respective sports sectors.

Research Objectives

This study aims to examine the implementation of the Identification and Development of Sports Talent Program based on Permenpora No. 6 Year 2022. The specific objectives are as follows:

1. To assess the level of effectiveness of policy implementation factors, namely communication, resources, disposition of attitude, and bureaucratic structure, in the implementation of the program among IGORNAS members in D.I. Yogyakarta and Central Java.

2. To identify which policy implementation factor has the most positive impact on the success of the program, based on the perceptions of physical education teachers.

3. To analyze the challenges faced by program implementers during the implementation process, using qualitative insights from open-ended responses.

4. To propose practical recommendations for improving the effectiveness and sustainability of the Identification and Development of Sports Talent Program in the future.

Conceptual Framework

From the observed literature above, this thesis will develop a framework as follows:

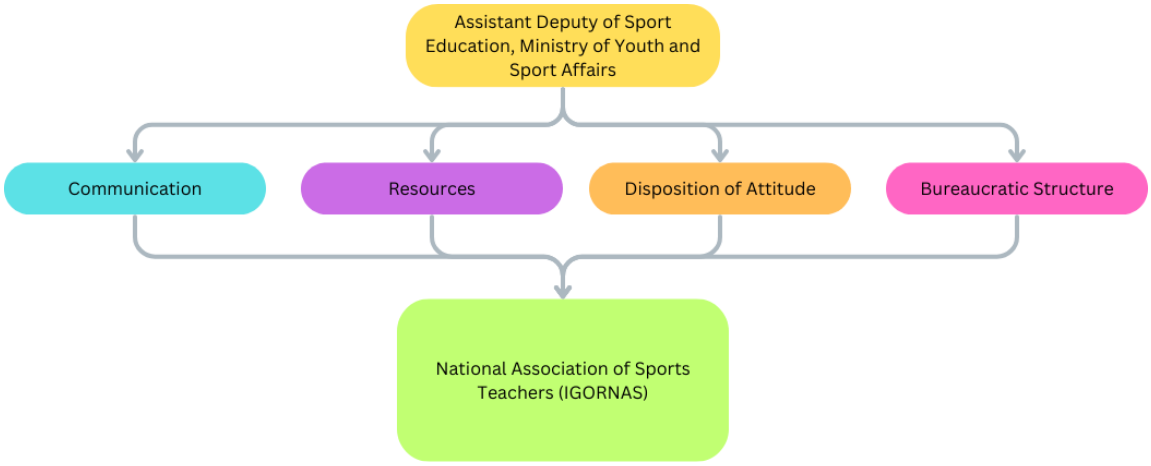


Figure 1 Conceptual Framework of The Implementation of Identification and Development of Sports Talent Program

To improve Indonesia's overall performance in future international competitions, they need to identify and develop future talents that possess competitive physicalities. Therefore, KEMENPORA, or Indonesia's Ministry of Sports and Youth Affairs, through the Assistant Deputy of Sport Education established the Identification and Development of Sports Talents Program, which is a part of Permenpora No. 6 Year 2022. The implementation of the Identification and Development of Sports Talents Program is distributed from the KEMENPORA as the policymaker at the central level to all provinces

in Indonesia through cooperation with the National Association of Sports Teachers (IGORNAS). IGORNAS of a specific province, in this study, D.I Yogyakarta and Central Java are responsible for implementing the program at selected schools. To make sure the policy implementation process is effective, the factors of effective policy implementation by Edwards (1980) need to be fulfilled, which are communication, resources, disposition of attitude, and bureaucratic structure. Successful implementation of the program will increase the number of potential athletes to be discovered and developed, and hence potentially enhancing the competitiveness of Indonesia in international sporting competitions, particularly in fields that they were previously lacking. This means that the quality and quantity of potential athletes as human resources in Indonesia will be enhanced.

Methods

This study used a mixed-method research method, using a descriptive quantitative approach to analyze the close-ended responses and text analysis to analyze the open-ended responses. Descriptive quantitative research refers to the utilization of numerical data in order to provide detailed and comprehensive analysis, which can help to describe or interpret a certain phenomenon or events (Mertler, 2017). Research subjects was the members of Indonesia's National Association of Physical Education Teachers (IGORNAS), specifically in the province of D.I. Yogyakarta and Central Java. The population of this survey consists of 70 members of IGORNAS who are involved in the Identification and Development of Sports Talent Program across from D.I Yogyakarta and Central Java. This survey was distributed through the WhatsApp group chat that contains members of IGORNAS in the D.I. Yogyakarta and Central Java, and gathered 37 respondents.

Questionnaire used the variables of effective policy implementation by Edwards (1980) as the basis of the questions. The questions are divided into four sections based on the theory, which are: [1] Communication, [2] Resources, [3] Disposition of Attitude, and [4] Bureaucratic Structure. There are three questions in each categories well as, and follow-up open-ended questions. The close-ended questions were formulated using the Likert scale, where the respondents were given a range from 1 to 5 to rate their satisfaction in each category.

Table 1 Survey Questions

	Q1	Q2	Q3
Communication	How well would you rate the effectiveness of communication within the DIY and Central Java IGORNAS?	Do you recognize the purpose and goal of this program?	According to your opinion, did the students recognize the purpose and goal of this program?
Resources	Do you think the number of physical education teachers who are involved in this program is sufficient enough?	How well would you rate the facilitation from KEMENPORA and Sport Experts to conduct this program?	Are the facilities and infrastructure in your school up to the standard for this program?
Disposition of Attitude	How easy was the program to be conducted? What are the challenges that you faced in conducting this program? (open ended)	Is the incentive from KEMENPORA enough to guarantee your commitment to coordinate this program?	How difficult was it for you to understand the standard operation procedure in measuring the student's anthropometry?
Bureaucratic Structure	Was ASDEP ORDIK KEMENPORA RI helpful enough to respond to your challenges while coordinating this program?	Was the IGORNAS of your region helpful enough to respond to your challenges in conducting this program?	Was the guide book of Anthropometric Measurement that was provided by KEMENPORA helpful?

The data analysis in this study was conducted using both quantitative and qualitative approaches. For the quantitative data, responses from the Likert-scale questionnaire were analyzed using descriptive statistics, including mean, median, and mode, in order to determine the level of effectiveness of each policy implementation factor, namely communication, resources, disposition of attitude, and bureaucratic structure. The interpretation of the mean scores was based on the Likert scale classification to categorize the results into levels such as high and very high.

For the qualitative data, responses from open-ended questions were analyzed using NVivo software through text analysis techniques. This process involved coding the textual data, identifying frequently occurring words, and generating a word cloud to visualize dominant themes. The qualitative findings were then used to support and enrich the quantitative results by providing deeper insights into the challenges faced by program implementers.

Results and Discussion

Analysis of the data collected through surveys administered to 37 respondents out of 70 physical education teachers who are also members of National Association of Sport Teacher also known as IGORNAS specifically in the province of D.I. Yogyakarta and Central Java.

1. Respondents Characteristics

In conducting this survey, the author gathered the data in one week. With a sample population of 70 teachers, this survey was able to get 37 respondents. Based on the survey result, 51,4% of the respondents are elementary school physical education teachers. Followed by 24,3% of both junior high school and senior high school physical education teachers. The percentage of elementary school physical education teachers tends to be higher compared to the others because the Identification and Development of Potential Sports Talent Program, which includes the Anthropometric Test, focuses more on younger children and is mostly held in elementary schools.

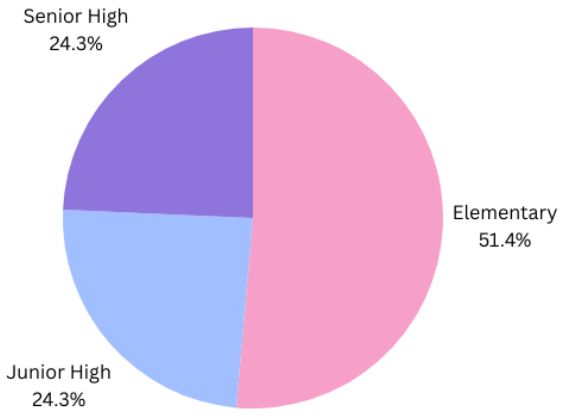


Figure 2 Educational Stages Taught by Respondents

The respondents who filled out this survey are based in seven different regencies in Central Java and D.I Yogyakarta. The highest number of respondents is based in Klaten, with the number of 8 teachers, which accounts for 21.62% of the total respondents. As can be seen on the bar chart, the second highest number of respondents were from Kulonprogo and Rembang, with both 5 respondents. Followed by Wonosobo, Yogyakarta, Bantul, Gunungkidul, Banjarnegara, and lastly, Demak, Karanganyar, and Sleman, with only 1 respondent each.

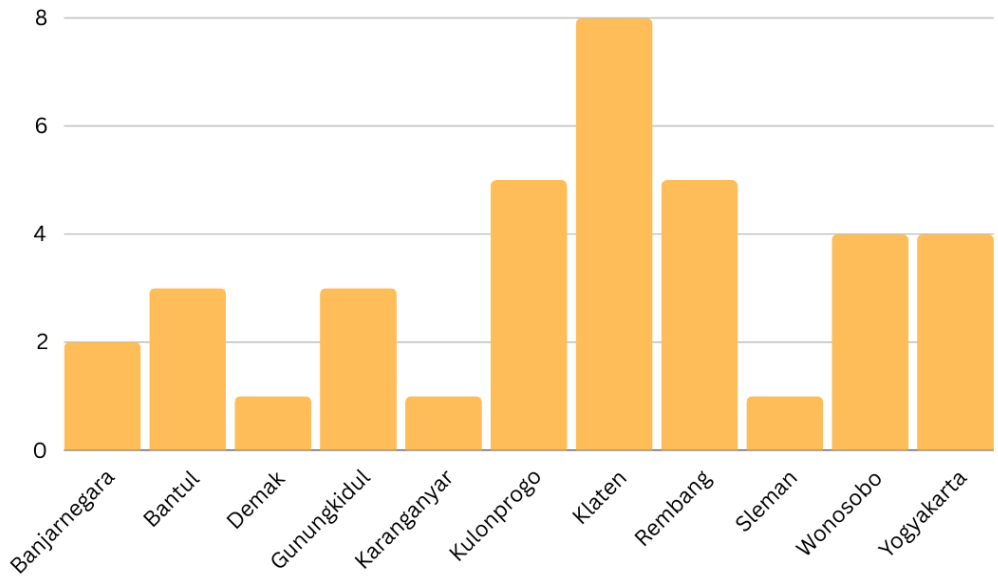


Figure 3 Regions of Respondents

2. Research Findings

The data results that have been gathered from the questionnaire, based on factors of successful policy implementation by Edwards (1980), which are communication, resources, disposition of attitude, and bureaucratic structure.

Communication

Q1. How well would you rate the effectiveness of communication within the D.I. Yogyakarta and Central Java IGORNAS? 43.3% of respondents considered the effectiveness of communication within the D.I Yogyakarta and Central Java's IGORNAS to be very high while the other 56.7% of respondents considered the effectiveness of communication high. There are no respondents who gave the score below high.

Q2. Do you recognize the purpose and goal of this program? 29.8% of respondents very highly recognize and understand the purpose and goal of this program, and 70.2% highly recognize the purpose of this program.

Q3. According to your opinion, did the students recognize the purpose and goal of this program? According to 13.52% of respondents, their students very highly recognize the purpose and goal of this program. 78.37% of respondents think that their students highly recognize the purpose of this program, and the other 8.11% of respondents believe that their students do lowly recognize the purpose and goal of this program.

From the total responses in the communication category, the average score which the respondents gave was 4.23. Meanwhile, the middle value of the total score given by the respondents was 4, and the score that was frequently given by the respondents was 4. According to the scale proposed by Likert, the average score is considered to be very high.

Resources

Q1. Do you think the number of physical education teachers who are involved in this program is sufficient enough? According to 2.70% of respondents, the number of physical education teachers who are involved in this program is very highly sufficient. Followed by 48.65% of respondents who think that the number is highly sufficient. Another 37.83% of respondents believe that the number of physical education teachers are lowly sufficient and 10.82% of respondents believe that the number of teachers is very lowly sufficient.

Q2. How well would you rate the facilitation from KEMENPORA and Sport Experts to conduct this program? According to 5.41% of respondents, the facilitation which they got from KEMENPORA had been very highly good. Another 94.59% of respondents think that the facilitation from KEMENPORA is highly good.

Q3. Are the facilities and infrastructure in your school up to the standard for this program? According to 5.41% of respondents, the facilities and infrastructures in their school is very up to the standard of this program. Another 62.16% of the respondents' school infrastructure is highly up to the standard and the rest 32.43% of respondents believed that their school facilities are not up to the standard for this program.

From the total responses in the resource's category, the average score that the respondents gave was 3.47. Meanwhile, the middle value of the total score given by the respondents was 4, and the score that was frequently given by the respondents was 4.

According to the scale proposed by Likert, the average score is considered to be high.

Disposition of Attitude

Q1. How easy was the program to be conducted? According to 72.97% of respondents, the program is easy to conduct. The other 27.03% of respondents believed that the program is not easy to conduct.

Q2. Is the incentive from KEMENPORA enough to guarantee your commitment to coordinate this program? According to 8.11% of respondents, the incentive that they received from KEMENPORA was more than enough to guarantee their commitment. Another 91.89% of respondents felt that the incentive is enough to guarantee their commitment in coordinating this program.

Q3. How easy was it for you to understand the standard operation procedure in measuring the student's anthropometry? According to 2.70% of respondents, it was very easy to understand the standard operation procedure in conducting this program. Another 83.78% of respondents believed that it was easy to understand the standard operation procedure. 8.11% of respondents felt difficult to understand and 5.41% respondents felt very difficult to understand the standard operation procedure in measuring the student's anthropometry.

From the total responses in the disposition of attitude category, the average score which the respondents gave was 3.78. Meanwhile, the middle value of the total score given by the respondents was 4, and the score that was frequently given by the respondents was 4.

Bureaucratic Structure

Q1. Was ASDEP ORDIK KEMENPORA RI helpful enough to respond to your challenges while coordinating this program? According to 8.11% of respondents, ASDEP ORDIK KEMENPORA was very helpful in responding to their challenges in coordinating this program. 81.08% of respondents felt that ASDEP ORDIK was helpful. Another 8.11% of

respondents believed that ASDEP ORDIK was not helpful and 2.70% of respondents felt that ASDEP ORDIK was very not helpful in responding to their challenges.

Q2. Was the IGORNAS of your region helpful enough to respond to your challenges in conducting this program? According to 2.71% of respondents, IGORNAS in their area is very helpful in responding to their challenges in conducting this program. 83.78% of other respondents felt that IGORNAS in their area are helpful. The other 13.51% of respondents felt that IGORNAS is not helpful in responding to their challenges in conducting this program.

Q3. Was the guide book of Anthropometric Measurement that was provided by KEMENPORA helpful? According to 10.81% of respondents, the guide book of Anthropometric Measurement that was provided by KEMENPORA was very helpful. 86.49% of respondents felt that the guide book was helpful and the other 2.70% of respondents felt that the guide book was not helpful.

From the total responses in the bureaucratic structure category, the average score which the respondents gave was 3.88. Meanwhile, the middle value of the total score given by the respondents was 4, and the score that was frequently given by the respondents was 4. According to the scale proposed by Likert, the average score is considered to be high

3. Qualitative Analysis: Text Analysis (NVIVO)

Based on the open-ended questions in the disposition of attitudes section, 10 out of 37 respondents stated that the Talent Identification and Development Program was challenging and wrote down their difficulties in conducting this program. The author uses NVivo software to analyze the responses using text analysis methods. The analysis was performed in order to gather the most frequent words generated by the respondents and create a visual representation of the word cloud to show the result. The result is as follows:



Figure 4 Word Cloud

From this word cloud, it is visible that the most frequent words that came out are "time", "short" and "test". Other words include "procedure", "cademic", "difficult", "internet", "teachers", "allocated", "given", "calendar", "signal" and "tests". The implications regarding the frequent words will be elaborated in the following section.

4. Discussion of Findings

This section will discuss findings gathered from the quantitative and qualitative methods that were used previously. By looking at the findings above, we can observe that there are four factors that are observed, which are communication, resources, disposition of attitude and bureaucratic structure. To determine which factor(s) had a huge impact on the level of success of Identification and Development of Sports Talent Program, three questions were distributed to the respondents.

Table 3 Mean, Median and Mode

	Communication	Resources	Disposition of Attitude	Bureaucratic Structure
Mean	4.23 (Very High)	3.47 (High)	3.78 (High)	3.88 (High)
Median	4 (High)	4 (High)	4 (High)	4 (High)
Mode	4 (High)	4 (High)	4 (High)	4 (HIgh)

By observing the overall average, middle value, and the most frequent score given by the respondents or its central tendency, the author concluded that all of the factors received a score 4 in terms of their middle value and the most frequent score, which indicates that generally, all respondents believe that all four factors have been implemented in a highly effective manner. However, the average score of each factor was slightly different. Communication received an average score of 4.23, resources received 3.47, disposition of attitude received 3.78, and bureaucratic structure received 3.88. The Likert scale is used to further categorize the average score between high or very high.

Looking at the information above, communication, which the average score is considered very high based on Likert Scale has the most positive impact on the implementation of the Identification and Development of Sports Talent Program from Permenpora No. 6 Year 2022, meanwhile resources has the lowest score, meaning that the category needed the most improvement. Based on the information previously elaborated, Communication—which score is considered very high based on Likert Scale—has the most positive impact on the implementation of the Identification and Development of Sports Talent Program, meanwhile Resources needs more improvement, as it has the lowest score.

A high score in communication means that the instructions given by ASDEP ORDIK KEMENPORA are received clearly by the members of IGORNAS DIY and Central Java who are involved in this program. The physical education teachers as well as the students both understand the purpose and goal of this program clearly.

Although the score differences were not that much, resources got the lowest score among other factors. A low score in resources means that members of IGORNAS DIY and Central Java are not satisfied with the resources that they had and that are provided by KEMENPORA to conduct this program. However, the average score of Resources is still considered high according to the Likert Scale. There are also some challenges that the physical education teachers were facing while conducting this program, especially in the Disposition of Attitude factor. Looking at the result from the text analysis method by Nvivo which analyzed the responses from the question above, words that frequently appeared were "time", "short" and "test". Other words include "procedure", "academic", "difficult", "internet", "teachers", "allocated", "given",

"calendar", "signal" and "tests". Based on the frequently mentioned words, the author concluded that there are 3 major challenges faced by IGORNAS, mentioned as follows:

1. Short Allocated Time
2. Difficult Procedure
3. Bad Internet Signal

Conclusion

After the data collection and analysis process, this last chapter will present the conclusion of this research as well as the implications for practice. In particular, it synthesizes key empirical findings derived from both quantitative and qualitative evidence, ensuring that the conclusions are grounded in a comprehensive interpretation of the data. By understanding which variable(s) influenced the success and failure of the implementation process, the result of this research can be used to determine which factor should be maintained and which factor should be improved and developed further. These insights not only clarify causal relationships among variables but also provide a deeper understanding of contextual conditions that may affect program effectiveness across different settings. By looking at the findings and discussion presented previously, this section will deliver a set of recommendations which aims at addressing the challenges and enhancing the successful policy implementation factors within the implementation of Identification and Development of Sports Talent Program by members of IGORNAS DIY and Central Java that were discovered through the survey and data analysis. Furthermore, the recommendations are designed to be practical, actionable, and adaptable, enabling policymakers, practitioners, and stakeholders to apply them effectively in future program planning and implementation while also contributing to the broader body of knowledge in sports development and policy implementation.

Based on the findings of this study, several practical suggestions can be proposed to improve the implementation of the Identification and Development of Sports Talent Program. First, greater attention should be given to enhancing resource availability, particularly in terms of increasing the number of personnel, improving school facilities, and ensuring adequate infrastructure to support program activities. Second, the implementation process should be supported by more flexible scheduling and better

time allocation, considering that limited time was identified as a major challenge by the implementers. Third, efforts should be made to simplify and standardize operational procedures to reduce difficulties faced by physical education teachers during the testing process. In addition, improving internet connectivity and technical support is essential to ensure smoother data collection and reporting. Finally, continuous communication and feedback mechanisms between IGORNAS and KEMENPORA should be strengthened to support adaptive policy implementation and ongoing program improvement across regions.

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Empowering Lives through Football: A Narrative Review of the Homeless World Cup as a Sport-Based Intervention for Social Inclusion

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Abstract

Homelessness is a multidimensional form of social exclusion rooted in trauma, stigma, and structural inequality, requiring interventions that extend beyond housing provision alone. Sport-based initiatives have emerged as complementary approaches to psychosocial engagement, yet their mechanisms and sustainability remain underexplored. This review offers a mechanism-oriented synthesis of the Homeless World Cup (HWC) as a global sport-based intervention for social inclusion, advancing a novel conceptual framing that positions the HWC as a psychosocial catalyst rather than a standalone solution. Using a narrative systematic review approach, peer-reviewed studies on the HWC, street soccer, homelessness, trauma-informed care, and public health were analyzed thematically. Findings indicate that participation fosters psychosocial empowerment, social capital development, identity reconstruction, and service engagement, primarily through recognition, belonging, and relational connection. However, outcomes are highly conditional upon institutional scaffolding, housing stability, and integrated health and social services. The discussion highlights the necessity of trauma-informed delivery and structural support, contributing a critical lens to sport-for-development scholarship and informing policy and practice for sustainable social inclusion.

Keywords: Homelessness; Sport for Development; Social Inclusion; Homeless World Cup; Football

Introduction

Homelessness and social exclusion remain among the most complex and persistent social challenges worldwide. Beyond the absence of stable housing, homelessness is frequently associated with cumulative experiences of trauma, disrupted social relationships, stigma, and long-term disengagement from social institutions (Côté et al., 2022; Fitzpatrick, 2017). These conditions often create a cycle of marginalization in which individuals face barriers to accessing employment, healthcare, and social support systems, further reinforcing their exclusion over time. Globally, approximately 100 million individuals experience homelessness, while over 1.6 billion lack adequate housing, underscoring the urgency of comprehensive and multidimensional responses (Donnelly et al., 2024). Traditional policy interventions, including emergency shelters and permanent supportive housing, have demonstrated effectiveness in improving residential stability but often fall short in addressing psychosocial recovery, identity reconstruction, and sustained social inclusion (Greenwood et al., 2020; Hwang & Burns, 2014). In particular, these interventions tend to prioritize material stability over relational and psychological dimensions, leaving critical aspects of reintegration insufficiently addressed.

In response to these limitations, sport-based interventions have gained increasing attention as complementary, low-threshold approaches to engaging socially excluded populations. Such interventions are often designed to reduce entry barriers by emphasizing participation rather than performance, thereby creating inclusive environments that are accessible to individuals with diverse backgrounds and capabilities. Sport offers embodied, relational, and symbolic experiences that may foster belonging, self-worth, and social connection, particularly for individuals who have experienced prolonged marginalization (Cowan & Taylor, 2016; Whitley et al., 2019). Through repeated participation, individuals may rebuild routines, develop trust, and experience positive social recognition, which are essential components of psychosocial recovery. However, scholars caution against uncritical claims regarding the transformative power of sport, emphasizing that outcomes depend on trauma-informed delivery, organizational capacity, and broader structural conditions (Magee, 2011; Whitley, 2022). Without appropriate support systems, sport programs risk producing only temporary engagement rather than long-term social change.

Among sport-for-development initiatives addressing homelessness, the Homeless World Cup (HWC) has emerged as one of the most prominent global interventions. Established in 2003, the HWC is an annual international football tournament designed to empower individuals experiencing homelessness while simultaneously challenging public perceptions and stigma. Research has documented psychosocial benefits for participants, including increased confidence, social capital, and renewed future orientations (Donnelly et al., 2024; Sherry, 2010). At the same time, critical evaluations highlight uneven outcomes across national contexts and question the sustainability of change without long-term institutional support (Magee & Jeanes, 2013).

Despite a growing evidence base, existing HWC literature remains fragmented and largely outcome-focused. Less attention has been paid to the mechanisms through which participation facilitates psychosocial change and the conditions under which such change can be sustained. Specifically, there is a need to examine how trauma-informed practices, the development of social capital, and the role of institutional ecosystems interact to shape participant outcomes. Accordingly, this review synthesizes interdisciplinary literature to examine the Homeless World Cup as a sport-based intervention for social inclusion, with particular emphasis on trauma, social capital, and institutional context. By shifting the focus from outcomes to underlying processes, this study aims to contribute a more nuanced understanding of how and when sport-based interventions can generate meaningful and lasting social inclusion.

Materials and Methods

Reporting and Registration

This study employed a narrative systematic review approach suitable for synthesizing qualitative, mixed-methods, and conceptual research. Given the heterogeneity of study designs and outcomes, meta-analysis was not appropriate. The review was not preregistered.

Eligibility Criteria

Studies were included if they:

1. Examined the Homeless World Cup or affiliated street soccer programs
2. Addressed homelessness, social exclusion, trauma, or social inclusion

3. Employed qualitative, quantitative, mixed-methods, or conceptual designs

4. Were published in peer-reviewed journals in English.

Information Sources and Search Strategy

Primary sources consisted of peer-reviewed journal articles provided by the user, supplemented by foundational literature on homelessness, trauma-informed care, and sport-for-development. Journals included Sport in Society, Psychology of Sport and Exercise, International Review for the Sociology of Sport, Health & Social Care in the Community, and BMC Public Health. Key terms included Homeless World Cup, street soccer, sport-based intervention, social capital, trauma, and homelessness.

Data Extraction

Extracted data included study context, methodology, participant characteristics, theoretical frameworks, reported outcomes, and identified limitations. Particular attention was paid to mechanisms of change and contextual factors influencing outcomes.

Data Analysis and Interpretation

An inductive thematic synthesis was conducted. Findings were organized into overarching themes: psychosocial outcomes, social capital development, identity reconstruction, service engagement, and structural constraints. Interpretation was guided by social exclusion theory and trauma-informed perspectives.

Results

The synthesized literature demonstrates that the Homeless World Cup and affiliated street soccer programs generate consistent psychosocial and social benefits for participants, though outcomes are highly context-dependent and contingent upon post-event support structures.

Psychosocial Outcomes

Across studies, participation in HWC-related programs was associated with increased self-esteem, confidence, emotional regulation, and hope for the future (Donnelly et al., 2024; Sherry, 2010). Narrative and qualitative research revealed that representing

one's country and being publicly recognized as an athlete fostered dignity and a sense of worth, particularly for individuals accustomed to invisibility and stigma.

However, longitudinal evidence indicates that these gains are often non-linear. Participants frequently experienced a "post-event crash," characterized by emotional withdrawal or maladaptive coping behaviors upon returning to structurally constrained environments (Donnelly et al., 2024). This underscores the fragility of psychosocial change in the absence of sustained support.

Social Capital and Relational Change

A central mechanism identified across studies was the development of social capital. Bonding social capital emerged through peer relationships among players with shared lived experiences, fostering trust and mutual support (Sherry & O'May, 2013). Bridging and linking social capital were facilitated through interactions with coaches, volunteers, and spectators, expanding participants' access to information, resources, and services (Sherry et al., 2011).

Identity Reconstruction

Participation enabled temporary identity transformation, allowing individuals to move from stigmatized identities associated with homelessness to valued roles as athletes and team representatives. Narrative studies illustrated how storytelling and embodied participation supported positive self-narratives and future-oriented identities (Donnelly et al., 2024; Whitley et al., 2022).

Service Engagement and Health Pathways

Sport-based participation functioned as a low-threshold entry point to health, housing, and employment services. This aligns with evidence from patient-centred care research demonstrating that trust-based, respectful relationships mediate access to care and improve subjective health outcomes among people experiencing homelessness (Flike et al., 2022).

Structural Constraints and Contextual Variation

Outcomes varied significantly across national contexts. High housing costs, limited welfare systems, and persistent stigma constrained participants' ability to translate psychosocial gains into stable life outcomes (Okada, 2021). The COVID-19 pandemic further

highlighted structural vulnerability, disproportionately affecting homeless populations and disrupting community-based interventions (Barocas et al., 2021).

Discussion

This review set out to critically examine the Homeless World Cup (HWC) as a sport-based intervention for social inclusion by synthesizing interdisciplinary literature across sport sociology, psychology, public health, and homelessness studies. Rather than assessing the HWC solely through outcome-based metrics, this discussion advances a mechanism-oriented and context-sensitive interpretation of how, why, and under what conditions football-based participation may contribute to psychosocial empowerment and pathways toward inclusion among individuals experiencing homelessness.

The Homeless World Cup as a Psychosocial and Relational Catalyst

Across the reviewed literature, the most consistent contribution of the Homeless World Cup lies in its capacity to function as a psychosocial and relational catalyst. Participation in football-based programs associated with the HWC repeatedly facilitates improvements in self-esteem, confidence, emotional regulation, and future orientation (Donnelly et al., 2024; Magee, 2011; Sherry, 2010). These outcomes are not incidental but emerge from specific experiential mechanisms embedded in the HWC model, including public recognition, collective identity, and embodied participation.

For individuals whose lives have been shaped by trauma, stigma, and prolonged social exclusion, the experience of being recognized as an athlete and national representative constitutes a meaningful disruption of dominant deficit-based identities. Narrative-based studies demonstrate how storytelling and symbolic representation allow participants to re-author personal narratives, shifting from identities defined by homelessness toward those associated with competence, resilience, and belonging (Donnelly et al., 2024; Whitley et al., 2022). This process aligns with trauma-informed perspectives emphasizing dignity, agency, and relational safety as foundational to recovery (Greenwood et al., 2020).

Importantly, the psychosocial benefits observed in HWC participation mirror findings from broader sport-based and youth development literature. Systematic reviews of sport-based interventions indicate that structured sport environments can foster

emotional regulation, social skills, and self-worth, particularly when programs are intentionally designed and supported by trained facilitators (D'Andrea et al., 2013; Whitley et al., 2019). However, the HWC literature also cautions that such benefits are fragile and may fluctuate over time, especially once participants return to environments characterized by housing instability, poverty, and stigma (Donnelly et al., 2024).

Thus, the HWC's primary contribution should be understood not as producing immediate structural change, but as initiating psychosocial processes that may support engagement with broader systems of care. This catalytic framing avoids romanticizing sport while acknowledging its potential role in trauma recovery and re-engagement.

Conditional Effectiveness: Structural, Health, and Policy Constraints

A central finding of this review is that the effectiveness of the Homeless World Cup is fundamentally conditional. Psychosocial empowerment generated through sport does not automatically translate into stable housing, employment, or long-term wellbeing. Instead, outcomes are mediated by structural conditions, welfare regimes, and access to integrated health and housing services.

Public health and homelessness literature consistently demonstrates that stable housing is the most robust predictor of improved health and social outcomes among homeless populations. Evidence from Housing First and permanent supportive housing models shows significant reductions in homelessness and improvements in health and service utilization when housing is provided without preconditions (Greenwood et al., 2020; Peng et al., 2020). In contrast, interventions that prioritize behavioral change without addressing housing insecurity tend to yield limited and unsustainable outcomes.

Within this context, the HWC functions most effectively when embedded within ecosystems that include housing, mental health care, substance use treatment, and case management. Research on patient-centred care among people experiencing homelessness further underscores the importance of trust-based, respectful relationships in mediating access to care and improving subjective health outcomes (Flike et al., 2022). Sport-based programs may facilitate such trust, but cannot substitute for systemic service provision.

The COVID-19 pandemic offers a stark illustration of these structural vulnerabilities. Studies examining homelessness during COVID-19 highlight how overcrowded

shelters, limited access to hygiene facilities, and structural barriers to testing and isolation disproportionately exposed homeless populations to health risks (Barocas et al., 2021; Hwang & Burns, 2014). These findings reinforce the argument that individual-level empowerment achieved through sport can be rapidly undermined by systemic crises when protective infrastructure is absent.

Moreover, structural stigma and policy environments play a decisive role in shaping post-participation trajectories. Research on social exclusion and victim-blaming demonstrates how societal attitudes toward homelessness—particularly toward women and survivors of childhood abuse—can perpetuate exclusion and erode trust in institutions (Côté et al., 2022). In such contexts, sport-based gains may be insufficient to overcome entrenched barriers to housing and employment.

Social Capital, Storytelling, and Institutional Scaffolding

Social capital emerges as a key mechanism linking sport participation to inclusion, yet its role is complex and contingent. Studies of the HWC consistently document the development of bonding social capital through peer relationships among players with shared lived experiences, fostering trust, solidarity, and mutual support (Sherry et al., 2011). Bridging and linking social capital are also facilitated through interactions with coaches, volunteers, spectators, and service providers, expanding participants' access to resources and opportunities.

However, as critical evaluations note, social capital does not operate in a vacuum. The conversion of social ties into tangible outcomes depends on institutional scaffolding—organizational capacity, service integration, and policy alignment (Magee & Jeanes, 2013; Okada, 2021). National Partner organizations play a pivotal role in this process, acting as intermediaries between the global spectacle of the HWC and the everyday realities of homelessness. Where these organizations are well-resourced and embedded within supportive welfare systems, HWC participation is more likely to contribute to sustained engagement with education, employment, and housing pathways.

Storytelling represents another distinctive feature of the HWC model. Narrative practices—both formal and informal—allow participants to articulate experiences of trauma, resilience, and hope, contributing to identity reconstruction and public awareness (Donnelly et al., 2024; Whitley et al., 2022). At the societal level, storytelling has been shown to

challenge negative stereotypes and foster attitudinal change among spectators (Sherry et al., 2011). However, ethical tensions arise when personal narratives are selectively amplified or framed in ways that emphasize individual transformation while obscuring structural constraints. Without critical contextualization, such narratives risk reinforcing meritocratic assumptions and shifting responsibility away from social policy.

Insights from research on media use and coping following social exclusion further enrich this discussion. A systematic review of media-based coping strategies suggests that individuals actively seek tools to restore emotional equilibrium and social needs after exclusion, with positive effects observed in a majority of cases (Lutz et al., 2023). Sport-based storytelling may operate similarly, providing meaning-making and emotional regulation, yet its long-term effectiveness remains contingent on structural support.

Taken together, these findings reinforce the central argument of this article: The Homeless World Cup is best understood as a catalyst embedded within a broader institutional and policy landscape. Its strengths lie in facilitating engagement, dignity, and relational connection, but its limitations underscore the necessity of coordinated, trauma-informed, and housing-linked interventions.

Conclusion

This review has critically examined the Homeless World Cup as a sport-based intervention for social inclusion, drawing on interdisciplinary evidence from sport studies, psychology, public health, and homelessness research. The synthesis demonstrates that football-based participation can generate meaningful psychosocial benefits, including enhanced self-worth, social connection, and renewed future orientation among individuals experiencing homelessness. These benefits emerge through mechanisms of recognition, identity reconstruction, and social capital development, positioning the Homeless World Cup as a powerful catalyst for engagement rather than a definitive solution to homelessness.

At the same time, the review underscores the conditional nature of sport-based empowerment. Psychosocial gains achieved through participation are inherently fragile when disconnected from stable housing, integrated health services, and supportive policy environments. Evidence from Housing First, patient-centred care, and COVID-19 responses highlights that structural interventions remain indispensable for sustained

wellbeing and inclusion. Sport-based initiatives such as the Homeless World Cup can complement—but not replace—comprehensive housing and health strategies.

By shifting analytical focus from outcomes to mechanisms and contexts, this article contributes a more realistic and theoretically grounded understanding of sport-for-development interventions. It highlights the importance of trauma-informed delivery, institutional scaffolding, and ethical storytelling in maximizing positive impact while avoiding over-romanticized narratives of individual transformation. For policymakers and practitioners, the findings emphasize the need to embed sport-based programs within coordinated service ecosystems that address both psychosocial and material dimensions of exclusion.

Future research should prioritize longitudinal and comparative designs capable of tracing how sport-based engagement interacts with structural opportunity over time. Evaluations that integrate participant narratives, process indicators, and policy context will be essential for advancing evidence-informed practice. Ultimately, the Homeless World Cup reminds us that meaningful social inclusion begins not with goals scored on the pitch, but with sustained commitments to dignity, housing, health, and social justice beyond it.

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The Development of Legal Frameworks for Recyclable Waste Management by Local Government Organizations

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Abstract

This research article aim to study the issues of participation by producers and the public in the management of recyclable waste, by comparing foreign laws and proposing guidelines for the development of Thai legislation. The research is based on a qualitative research, by conducting document research, analyzing provisions of Thai law, foreign laws, and relevant academic documents.

Research findings show that Thai law lacks provisions that clearly define the duties of producers and the public in separating and managing recyclable waste, and there are no economic measures to create incentives. As a result, the burden of waste management mainly falls on local government organizations, leading to less effective recycling management. In contrast, the laws of the Federal Republic of Germany, the Republic of Korea (South Korea), and Japan clearly define the responsibilities of producers and the public and use economic measures to promote tangible participation. Therefore, Thailand should develop its laws by specifying duties for separating recyclable waste, defining the responsibilities of producers, and implementing economic measures to sustainably improve the efficiency of recyclable waste management by local government organizations.

Keywords: Legal Framework, Recyclable, Waste Management.

Background and Statement of the problem

Environmental issues are a crucial aspect of national development, as natural resources are fundamental to human life and economic and social development. Environmental policy aims to maintain environmental quality for sustainable development,

a concept that emphasizes the balanced use of natural resources while preserving environmental quality for the benefit of present and future generations. Thailand has established important legal mechanisms, including the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), which sets environmental quality standards and mechanisms for pollution prevention and control, as well as the Polluter Pays Principle. (Sureeporn Salapsri, 2024)

Currently, waste is one of the world's major environmental problems, including in Thailand, which has to deal with continuously increasing amounts of solid waste. This is a result of urban growth, higher consumption by the population, changes in resource use behavior, and the convenience-driven online ordering of products and food. All of these factors contribute to the rising amount of municipal solid waste and plastic waste, which have impacts on the environment, public health, and people's quality of life. Particularly, if recyclable waste is properly managed, it can create economic value and reduce environmental impact. The key principle in internationally recognized waste management is the 3Rs: Reduce, Reuse, and Recycle. This approach aims to reduce waste at the source, promote efficient resource utilization, and minimize long-term environmental impact. (Atthachai Donjunla and Sudabhorn Khitkhulnamchai, 2025)

In the context of local governance in Thailand, waste management is a crucial responsibility of local administrative organizations. This aligns with the principle of decentralization, which aims to enable local agencies to effectively manage resources and address problems in a manner consistent with local conditions and the needs of the people. Laws concerning decentralization stipulate that local administrative organizations play a vital role in the conservation of natural resources and the environment, including waste management within their areas. (Sunee Mallikamarl, 2026)

Waste Volume Statistics in Thailand, 2024: Thailand generates approximately 26.95 million tons of solid waste. It was found that 9.31 million tons (34.5%) of solid waste were recycled, 10.17 million tons (37.7%) were properly disposed of, and 7.47 million tons (27.7%) were improperly disposed of (National Statiscal Office, 2024) From the information above, the recycling rate statistics remain low. If recyclable waste is not managed properly, it will have a negative impact on the environment, causing various forms of pollution such as foul odors, wastewater, disease-carrying pests, and contributing

to an increase in global atmospheric temperature. Part of this problem is the lack of participation from producers and the public in managing recyclable waste, as follows. (Thai PBS, 2024)

The problem of participation by producers and the public in managing recyclable waste, especially the sorting of recyclable or reusable waste, currently lacks cooperation from the public. Even though the Act On The Maintenance of The Cleanliness and Orderliness of the Country, B.E. 2535 (1992) stipulates the duties of individuals and local authorities, Section 8 (2) requires owners or possessors of buildings or land not to neglect waste disposal on their property. Combined with Section 54, violators are subject to a fine of up to two thousand baht. Sections 6 and 7 specify the duties of building owners or occupants to maintain cleanliness of sidewalks and surrounding areas, and Section 33 in conjunction with Section 57 sets a fine of up to 10,000 baht. It can be seen that this Act focuses on cleanliness, prohibiting littering in public places and stipulating fines only for those who dispose of waste improperly. However, it does not establish any measures requiring people who dispose of reusable or recyclable waste to separate it before disposal, nor does it impose any fines for failing to do so. This results in a lack of public participation in waste separation, leading to mixed waste that is not sorted from the source and wasting local budgets on separating recyclable waste. Furthermore, local administrative organizations lack mechanisms to enforce citizens' responsibility for source waste separation. In comparison, South Korea uses economic measures to create both negative and positive incentives regarding whether to charge a fee for recyclable waste collection. (Yongjin Lee, 2019)

For waste generators, according to the Ministerial Regulation Hyienic Waste Management B.E. 2560 (2017) Section 2, which states, "waste producer" means dwellers and the owner or the possessor of a building, establishment, service center, industrial factory, market place, or other places in which waste is generated. The Ministerial Regulation is stipulated to cover producers in generating waste as follows. To make the law enforceable, it is necessary to clearly define the duties for sorting recyclable waste, following the examples of the Federal Republic of Germany and Japan. Local administrative organizations should be empowered to implement administrative measures, and producers should be held responsible for packaging based on the "polluter pays principle"

principle, establishing producer responsibility. Solving the recyclable waste problem at the local level cannot rely solely on citizens sorting waste at the source or on local administrative organizations collecting waste at the endpoint. It is essential for private sector producers to participate as well, in order to manage recyclable waste effectively and sustainably.

The Constitution of the Kingdom of Thailand, B.E. 2560 (2017) places great importance on the process of public participation. It provides avenues for people to participate through the exercise of direct rights. Provisions regarding community rights and the state's duties related to the management of natural resources and the environment are presented in two parts as follows. The first part is the provisions in Chapter 5 on the Duties of the State. Section 57 (2) stipulates that the state has the duty to conserve, protect, maintain, restore, manage and use or arrange for utilisation of natural resources, environment and biodiversity in a balanced and sustainable manner, provided that the relevant local people and local community shall be allowed to participate in and obtain the benefit from such undertaking as provided by law. Part Two, provisions in Chapter 3 concerning the rights and Liberties of the Thai people, Section 43, stipulates that both individuals and communities have the right to manage, maintain, and benefit from natural resources and the environment, as well as biodiversity. The aforementioned section is directly related to public participation and the duty to care for the environment as prescribed by law.

Therefore, this research article aim to study the development of laws for the management of recyclable waste by local administrative organizations. The study scope focuses on issues of participation by producers and the public in recyclable waste management under Thai law and compares international approaches, in order to provide recommendations for the development of laws on recyclable waste management for local administrative organizations in Thailand.

Objective

1. To study the issues of participation by producers and the public in recycling waste management.

2. To study concepts, theories, and principles related to the development of legal frameworks for recyclable waste management by local government organizations.

3. To study Thai law and foreign laws related to the development of legal frameworks for recyclable waste management by local government organizations.

4. To develop proposals for guidelines on improving the development of legal frameworks for recyclable waste management by local government organizations.

Expected benefits

1. Received an understanding of the issues regarding the participation of producers and the public in managing recyclable waste.

2. Received knowledge of concepts, theories, and principles related to the development of legal frameworks for recyclable waste management by local government organizations.

3. Received knowledge about Thai laws and foreign laws related to the development of legal frameworks for recyclable waste management by local government organizations.

4. Received proposals for developing legislation on the development of legal frameworks for recyclable waste management by local government organizations.

Research Methodology

The qualitative research by document research has established a procedure for conducting qualitative research, which includes data collection through documentary research. The focus is on analyzing relevant documents such as concepts, theories, principles, Thai laws, foreign laws, as well as various academic documents, information from the internet, and related research data to study the development of legislation for the management of recyclable waste by local administrative organizations.

Research Results

From the study of the participation issues of producers and the public in managing recyclable waste under Thailand's legal system, analyzed alongside the concepts, principles, and theories of environmental law, and compared with foreign laws, it was found that current Thai law still has structural limitations in defining the duties and responsibilities of those involved with recyclable waste. This results in an inability to establish a legal mechanism to genuinely enforce participation.

1. Issues with producer participation in managing recyclable waste

The study found that, according to the Public Health Act B.E. 2535 (1992), Sections 18 and 20, which grant local administrative organizations the authority to manage waste, as well as the Ministerial Regulation Hyienic Waste Management B.E. 2560 (2017), Clause 2, which states that "waste producer" means dwellers and the owner or the possessor of a building, establishment, service center, industrial factory, market place, or other places in which waste is generated. the ministerial regulation also includes producers as waste generators. Although these provisions legally establish producers as 'waste generators,' the law does not specify any particular responsibility for producers to manage recyclables generated from their products.

This issue reflects the gap in Thai law regarding the legal duties of producers, which differs from merely defining them as 'waste generators.' Assigning a status without corresponding duties or enforcement measures does not produce practical effects. Since the law does not establish duties and enforceable conditions, it cannot create legal liability. In other words, although producers may be the factual generators of waste, they are not legally responsible.

Such a structure contradicts the Polluter Pays Principle, which is a fundamental principle of environmental law. The Polluter Pays Principle is an environmental economic concept that requires those who cause pollution to be responsible for the damage and environmental costs incurred. (Nattha Tanayapong, 2015) and it is an economic tool to make prices reflect the true environmental costs. (Waranan Tantiwat et al, 2014) Polluters are required to bear the costs of remedying, compensating, and preventing environmental damage. (Ayukorn Boonakat, 2023) Which aims to prevent the costs from falling on society or the state, and to create fairness in terms of the environment.

(Sumittra Jhermpun, 2014) In legal terms, this principle is also applied in establishing legal measures, such as imposing fines or charging for environmental restoration costs. It is considered an important mechanism that helps ensure accountability for the impacts of economic activities and helps reduce pollution problems in the long term. (Pitak Sasisuwan, 2024) In the past, producers or users of natural resources often did not include these costs in the prices of goods or services, resulting in the overuse and degradation of resources. (Udomsak Sinthipong, 2018) This principle is also similar to the user-pays principle and plays an important role in encouraging producers and consumers to change their behavior to reduce environmental impacts. (Muneeroh benkob, 2023) However, since Thai law does not stipulate the responsibility of manufacturers for recyclable waste, while Thai waste management laws and community waste management plans follow a linear economy model, the 'collection, transport, and disposal' process focuses on the responsibilities of local administrative organizations but does not assign duties to all sectors. This makes the management of the problem still incomplete throughout the system, lacking a source-separation system, and there is still no specific Waste Management Act or Packaging Waste Management Act. (Sujitra Vassanadumrongdee, 2021)

In addition, when considered according to the Extended Producer Responsibility (EPR) theory, the concept requires producers to be responsible for the environmental impacts of products and packaging throughout their life cycle. (Office of Natural Resources and Environmental Policy and Planning, 2024) From design and production to post-consumption management, especially the establishment of a system for product or packaging returns to reduce waste and increase recycling efficiency, this principle helps to distribute the responsibility from local government authorities to producers and consumers, who are the ones generating the waste. It helps address waste management issues caused by not sorting waste at the source and serves as a principle to encourage producers to take environmental responsibility to reduce waste problems. (Public Relations Department, 2023)

Compared to foreign laws, for example, the Federal Republic of Germany has adopted the principle of Extended Producer Responsibility (EPR), which is codified in the law on packaging waste management, namely The Ordinance on the Avoidance of

Packaging Waste (BGB1. I 1991 S. 1234). The state uses the principle of Extended Producer Responsibility (EPR) as a policy tool to require producers or brand owners in each industry to be responsible for packaging and product waste throughout the product's life cycle after consumption. Producers must participate in establishing take-back systems to collect and manage such waste effectively. This measure aims to reduce the burden on local authorities responsible for managing packaging and product waste. Although the principle of increased producer responsibility focuses primarily on the role of producers, in establishing legal measures, the state has also extended responsibility to other relevant sectors, such as retail operators, local governing bodies, and consumers. (Sujitra Vassanadumrongdee, 2020) And the deposit–refund system (Pfand) for beverage bottles and cans, where consumers receive a refund when they return the packaging. This system results in a return rate of up to 98 percent for bottles in Germany. (Martina Igini, 2022) It also creates a direct economic incentive by allowing the public to return bottles or cans at collection points in stores to receive their deposit back, which encourages participation. The purposes of the Deposit–Refund System are: 1) to create an economic incentive for the public to return packaging, 2) to reduce the amount of waste from beverage bottles and cans, and 3) to increase recycling rates, as the returned materials are sent to sorting systems and reused. In Japan, under Article 4 of the Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging, it is stipulated that 'Consumers must make efforts to reduce packaging use and separate packaging waste from other waste to promote effective recycling. (Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging (1995), Art. 4) (Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging, 1995) And as stipulated in Section Article 11(1) In conducting business activities, pursuant to the fundamental principles, businesses have the responsibility to take necessary measures to prevent or reduce the raw materials, etc. from becoming wastes, etc., in the course of business activities and when raw materials, etc. have become circulative resources in the course of business activities, businesses have the responsibility to undertake proper cyclical use of such resources themselves, or to take necessary measures to enable their proper cyclical use. In cases in which raw materials, etc. cannot undergo cyclical use, businesses have the responsibility to undertake their proper disposal, on their own

responsibility. (Basic Act for Establishing a Sound Material-Cycle Society (2000, Art. 11(1)). (Basic Act for Establishing a Sound Material-Cycle Society, 2000) These provisions reflect the principle of 'Extended Producer Responsibility (EPR),' which is an important tool for fostering collaboration between the government, private sector, and the public. In the Republic of Korea, an Extended Producer Responsibility (EPR) system is implemented, requiring producers and importers to take back and recycle their packaging or products at the end of their life cycle. Failure to comply incurs additional fees. This system helps alleviate the burden on local government organizations and promotes waste management through a circular economy approach. (Ministry of Environment of Korea, 2021)

It was found that all three countries have mandated that producers are legally obligated to take back and recycle their own packaging, and are responsible for the costs of carrying out these activities. This reduces the burden on local authorities and increases the efficiency of the recycling system. However, Thai law has not yet established this principle as a legal duty. As a result, the legal relationship between 'producers' and 'product-generated waste' is disconnected, leaving producers without a legal incentive to reduce waste or support recycling.

In conclusion, the problem of the lack of provisions clearly defining the responsibilities of manufacturers in managing recyclable waste is a major obstacle to developing an efficient and sustainable recycling management system.

2. The problem of lack of public participation in managing recyclable waste

The study found that although The Constitution of the Kingdom of Thailand, B.E. 2560 (2017) guarantees the rights and duties of the people to participate in the management of natural resources and the environment, related acts at the legislative level, such as the Act On The Maintenance of The Cleanliness and Orderliness of the Country, B.E. 2535 (1992), show that the law is intended to control public littering by prohibiting the disposal of waste or garbage in public places and setting penalties for offenders. However, the law does not stipulate the 'duty of citizens to separate recyclable waste.' Legally, this means that failing to separate waste is not considered an offense and cannot lead to punishment, resulting in public participation being voluntary rather than a legal obligation.

For a person to be legally liable, certain key elements must be present: 1. There is a legal provision establishing a duty, 2. The duty is breached, and 3. There is a binding condition. However, when the law does not specify a duty to separate waste, the first element does not occur, resulting in no legal liability, even though failing to separate waste affects the recycling waste management system.

From the aforementioned legal issues, when analyzed according to the concept of public participation, public involvement is considered a fundamental foundation for sustainable development. It also promotes the joint utilization of potential across various sectors to integrate participation in multiple areas, one of which is the effective conservation and management of the environment. (Laksamee Ketsakul and Chutarat Chompunth, 2016) The principle of public participation is an important universal principle in decentralization, allowing people to have a role in decision-making regarding administration and resource allocation that affects public benefits and quality of life. (Sirichai Kumanchan, 2023) Public participation is a key principle in environmental management and waste management systems. (Sujitra Vassanadumrongdee et al, 2022) The public must play a role both as 'rights holders' and 'duty bearers.' However, Thai law focuses on 'rights' but does not define 'duties,' which results in the public having no legal responsibility and remaining merely as 'recipients of government services,' despite being 'producers of waste.' At the same time, when analyzed according to the principles of environmental economics (Economic Incentives), economic incentives are financial measures used to adjust the costs for polluters so that they reflect the true environmental costs based on the 'polluter pays' principle, instead of relying on direct government mandates. Key measures include: 1. Environmental taxes and fees. Collecting environmental fees and taxes is an economic tool to make polluters responsible for environmental costs. (Warissanee Meekaeo, 2001) 2. Subsidies 3. Emission trading systems 4. Deposit–refund systems and 5. Environmental funds to encourage environmentally friendly behavior. Although these measures are more efficient and lower in cost than command-and-control approaches, they still have limitations in terms of fairness and the difficulty of setting appropriate rates. (United States Environmental Protection Agency, 2025) The use of economic tools helps improve the efficiency of pollution and waste management. (Office of Small and Medium Enterprises Promotion,

2023) The lack of such measures in Thai law has resulted in people having no economic incentive to separate their waste, leading them to throw it all together since there is no difference in cost.

Compared to foreign laws, such as in the Republic of Korea, South Korea uses a Volume-Based Waste Fee System (VBWF) since 1995, where citizens purchase garbage bags issued by local government organizations to dispose of general waste. Recyclable waste can be disposed of free of charge, which incentivizes citizens to separate waste from the source. (Yongjin Lee, 2019)

In conclusion, the problem of the lack of public participation in Thailand does not stem from the absence of rights recognition, but from the lack of legal mechanisms that clearly define duties and incentives, reflecting a discrepancy between legal principles and their practical implementation.

Summary of the study

The study on producer participation revealed that, although Thai law designates producers as waste generators under the Ministerial Regulation Hyienic Waste Management B.E. 2560 (2017), there are no provisions directly assigning producers responsibility for recyclable waste from their products or packaging. Producers, as the source of packaging and products that generate recyclable waste, do not have a legal obligation to directly manage waste generated from their products. Even though relevant laws designate producers as waste generators, they do not specify a duty to sort or recover recyclable waste. As a result, waste management responsibility remains primarily the burden of local administrative organizations. Furthermore, the study on public participation found that, despite the 2017 Constitution guaranteeing the right of citizens to participate in natural resource and environmental management, relevant waste management laws do not clearly define the public's duty to sort recyclable waste. Therefore, waste sorting remains voluntary, not a legal obligation.

Discussions

Research on the issue of producer and public participation in recycling management reveals that current Thai law lacks clear provisions defining the duties and responsibilities of producers and the public in sorting and managing recyclable waste. Most relevant laws focus primarily on defining the authority of local administrative organizations to collect, transport, and dispose of solid waste, without establishing concrete mandatory or economic incentives to encourage producer and public participation in waste sorting at the source. As a result, the burden of recycling management falls solely on local administrative organizations, leading to inefficient recycling management. This is because effective recycling management requires cooperation from all sectors, especially producers who are the source of packaging and products, and the public who are consumers and direct generators of waste. However, since Thai law does not clearly define these responsibilities, it is impossible to create incentives or enforce genuine participation. This differs from the laws of the Federal Republic of Germany, the Republic of Korea, and Japan, which clearly define the responsibilities of producers and the public, and utilize economic measures such as packaging deposit systems and waste-based fee systems to promote participation. As a result, these countries have more efficient recycling management and reduced the burden on local administrative organizations.

The research findings are consistent with the principles of environmental economics (Economic Incentives), which explain that the use of economic measures such as fees or incentives can help change the behavior of polluters to consider environmental costs and promote more environmentally friendly behavior. Furthermore, it aligns with the Polluter Pays Principle (PPP), which holds polluters responsible for the impacts and costs incurred, creating fairness and reducing the burden on the government. Simultaneously, the research aligns with the theory of Extended Producer Responsibility (EPR), which emphasizes that producers are responsible for their products throughout their life cycle, including the management of end-use products. This principle reduces the burden on local governments and improves the efficiency of recycling management. Finally, it aligns with the concept of public participation, which recognizes that public involvement is a crucial component in sustainable resource and environmental management, as citizens play a direct role in sorting and reducing waste at the source.

In summary, the main causes of producer and public participation in recycling management in Thailand stem from the lack of clear legal provisions and appropriate incentives. Developing laws that align with environmental economics principles, the polluter pays principle, producer responsibility theory, and the concept of public participation would promote concrete involvement and lead to effective and sustainable recycling management by local administrative organizations.

Recommendations

This research on "The Development of Legal Frameworks for Recyclable Waste Management by Local Government Organizations" focuses on the issue of producer and public participation in recycled waste management. The researchers have the following recommendations: Public participation in recycling waste management according to the Act On The Maintenance of The Cleanliness and Orderliness of the Country, B.E. 2535 (1992), which focuses on maintaining cleanliness, prohibits littering in public areas, and sets fines for improper disposal. To make the law enforceable, it is considered necessary to establish measures requiring those who dispose of recyclable waste to sort it before disposal and impose fines on those who fail to comply. As for the Public Health Act B.E. 2535 (1992) , which focuses on defining the responsibilities of local administrative organizations in waste management, the Act does not specify how the public should handle recyclable waste. Therefore, in order to make the law enforceable, it is deemed necessary to clearly define the duties of the public in managing recyclable waste. The public should separate recyclable waste from the source, and there should be measures to provide incentives, such as reducing fees or granting benefits to those who properly separate waste, or using economic measures to create negative or positive incentives regarding the collection or non-collection of recyclable waste fees. If these duties are not followed, there should be fines imposed. Producer Participation in Recycling Waste Management According to the Ministerial Regulation Hyienic Waste Management B.E. 2560 (2017), Section 2 states, "waste producer" means dwellers and the owner or the possessor of a building, establishment, service center, industrial factory, market place, or other places in which waste is generated. The ministerial regulation also applies to producers in generating waste. Therefore, to make the law enforceable, it is necessary to

clearly define the duties of sorting recyclable waste and to establish the responsibilities and scope of liability of producers in generating waste. Failure to comply may result in additional fees or legal penalties.

Suggestions for future research include whether there should be specific legislation on packaging waste management in Thailand, and what mechanisms for accountability throughout the product's life cycle should be established.

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School Management Strategies under Disruptive Change: A Review of School Management Strategies under Disruptive Change

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Abstract

This article aims to present a conceptual and empirical exploration of disruptive change driven by rapid technological advancement, shifting labor market demands, and global crises has fundamentally reshaped educational management worldwide. In Thailand, primary schools face increasing pressure to enhance students' digital competencies while navigating systemic constraints in policy, infrastructure, and human capital. This paper examines school management strategies under disruptive change, focusing on digital competency in Thai primary schools. Drawing upon policy analysis, case-based synthesis, and contemporary literature, the study proposes four strategic domains: (1) adaptive school management under disruptive change; (2) academic administration reform to promote students' digital competencies; (3) teacher capacity enhancement for digital competency development; and (4) flexible and responsive learning support systems. The findings suggest that effective digital competency requires systemic alignment between leadership, curriculum, pedagogy, and support structures.

Keywords: digital competency, disruptive change, school management, primary school, Thailand

Introduction

The 21st century has been characterized by rapid digital transformation, often conceptualized as "disruptive change" (Christensen, 1997, p. 12) In education systems globally, technological innovation has redefined learning environments, competencies, and institutional governance. The COVID-19 pandemic further accelerated digital adoption in schools, exposing structural inequities and management limitations (UNESCO, 2021, p. 18). These transformations have accelerated the transition toward what is often described as

a disruptive society—an environment in which traditional institutional models are continuously challenged by innovation and digital transformation. Within this context, primary education occupies a particularly critical position, as it lays the foundation for learners' lifelong competencies, adaptability, and digital citizenship. Consequently, school management can no longer rely solely on conventional administrative paradigms; instead, it must evolve toward adaptive models capable of responding effectively to continuous change.

Previous international studies have explored the relationship between digital transformation and educational leadership. For example, Dexter (2018) found that effective technology integration in schools depends heavily on leadership vision and organizational support structures. Similarly, Fullan and Langworthy (2014) emphasized that digital innovation in education requires systemic change involving pedagogy, leadership, and institutional culture rather than isolated technological adoption. Research by Harris and Jones (2020) further suggested that school leadership during disruptive contexts, such as the COVID-19 pandemic, plays a pivotal role in enabling adaptive decision-making and maintaining instructional continuity. These studies indicate that leadership and management strategies are key factors in facilitating digital transformation in schools.

In the Thai context, national reforms articulated in the 20-Year National Strategy (2018–2037) and Thailand 4.0 policy emphasize human capital development and digital capability enhancement (Office of the National Economic and Social Development Council [NESDC], 2018, p. 45). However, Effective educational reform requires strong school management and school administration to ensure that policies are translated into practical implementation at the institutional level (Bush, 2011; Hallinger & Heck, 2010). In the Thailand primary schools—particularly those under the Office of the Basic Education Commission (OBEC)—face persistent challenges in digital infrastructure, teacher preparedness, and leadership adaptability. In Thailand, policy initiatives led by the Ministry of Education (MOE) and the Office of the Basic Education Commission have underscored the importance of integrating digital technologies into teaching, learning, and school administration. These efforts align with broader socio-economic agendas aimed at enhancing national competitiveness and human capital development in the digital era. However, policy directives alone do not guarantee meaningful transformation

at the school level. The success of digital initiatives largely depends on how school leaders interpret, adapt, and implement reforms within their specific organizational contexts. Thus, the capacity for adaptive school management becomes a decisive factor in fostering genuine digital competency among primary school students.

Several studies in Thailand have also examined digital competency development and educational management. For instance, Chaiyasong (2019) reported that while Thai schools increasingly adopt digital technologies, many institutions lack systematic management strategies that integrate digital competency into academic administration. Likewise, Sangrà and González-Sanmamed (2016) highlighted that institutional leadership and strategic planning are crucial in supporting sustainable digital learning environments. Furthermore, Thongmak (2021) found that disparities in leadership capacity and resource allocation among primary schools contribute to uneven development of students' digital competencies. Despite these contributions, most existing studies primarily focus on technology integration or teacher digital literacy rather than examining comprehensive school management strategies that link leadership, academic administration, and student digital competency development.

School management strategies and academic administration are integrally interconnected in promoting students' digital competencies toward high-quality and effective outcomes. When schools establish clear management strategies that are coherently aligned with academic operations and grounded in a student-centered orientation, the development of students' digital competencies can be achieved in a sustainable manner and can meaningfully respond to the goals of education in the digital era.

School administration in the digital age requires strategic approaches that are explicit, systematic, and responsive to ongoing societal and technological transformations. In particular, strategies aimed at enhancing student quality through the development of digital competencies are essential, as such competencies constitute fundamental skills for learning and living in the twenty-first century. Scholars in educational administration argue that school management strategy serves as a critical framework guiding the direction, structure, and operational mechanisms of a school's core missions, especially academic administration, which directly influences student quality

Nevertheless, a critical knowledge gap remains in the literature. Existing research has largely addressed digital competency from the perspectives of technology adoption, teacher readiness, or policy frameworks, while comparatively limited attention has been given to how school management strategies operate in practice under conditions of disruptive change, particularly in primary school contexts. Moreover, there is insufficient empirical evidence explaining how school leaders strategically align academic administration, organizational culture, and digital competency development among students in rapidly changing educational environments. Therefore, investigating school management strategies within primary schools facing disruptive change is essential to deepen understanding of how leadership practices can effectively support the development of students' digital competencies. This study seeks to address this gap by examining the management strategies employed by primary schools to promote digital competency under conditions of educational disruption.

Effective school management strategies must therefore be cohesively linked with academic administration. This integration begins with the formulation of a clear academic vision and policy explicitly focused on advancing students' digital competencies. When school leaders successfully translate this vision into concrete academic action plans, curriculum development, instructional design, and assessment practices can proceed in a unified and coherent direction. In this regard, strategic management that systematically connects policy formulation with classroom-level implementation constitutes a decisive factor in achieving tangible and sustainable improvements in student quality.

Disruptive Change and Educational Leadership

Disruptive innovation theory posits that transformative change requires organizations to adapt structurally and culturally (Christensen, 1997, p. 102). In educational settings, adaptive leadership involves flexibility, distributed decision-making, and responsiveness to uncertainty (Fullan, 2014, p. 27). Digital transformation demands systemic integration rather than isolated technology adoption.

Disruptive change in education refers to systemic transformations driven by technological innovation, globalization, and shifting socio-economic demands that fundamentally alter organizational structures and pedagogical paradigms. Drawing on the

theory of disruptive innovation, Christensen (1997, p. 12) argues that disruption occurs when new technologies redefine value propositions and challenge established institutional models. In educational contexts, such disruption extends beyond technological adoption to encompass leadership practices, governance systems, curriculum structures, and stakeholder engagement.

The scope of disruptive change in educational leadership therefore includes:

1) Organizational Transformation – restructuring governance, decision-making processes, and institutional culture to foster agility and innovation (Fullan, 2014, p. 27).

2) Digital Ecosystem Integration – embedding digital technologies into curriculum, assessment, communication, and administrative systems.

3) Human Capital Development – strengthening teachers' and leaders' digital competencies to ensure sustainable transformation.

4) Equity and Access Considerations – addressing the digital divide to ensure inclusive participation in digitally enhanced learning environments (UNESCO, 2021, p. 18).

Transformative leadership in the digital era requires adaptive, visionary, and collaborative approaches. Heifetz and Linsky (2002, p. 35) emphasize that adaptive leadership involves mobilizing stakeholders to confront complex challenges that lack predetermined solutions. In the context of digital transformation, school leaders must foster a culture of experimentation, distributed responsibility, and continuous learning.
Strategy formation under disruptive change must bridge macro-level policy direction and micro-level classroom practice. Mintzberg (1994, p. 23) posits that effective strategy combines deliberate planning with emergent adaptation. In education, this implies aligning national or institutional digital policies with context-sensitive implementation.

To enhance students' digital competencies, strategic formulation should encompass:

1) Curriculum Integration – embedding digital literacy, computational thinking, and ethical technology use across disciplines.

2) Pedagogical Innovation – promoting inquiry-based, project-based, and blended learning models that cultivate higher-order digital skills.

3) Assessment Reform – implementing authentic and performance-based assessment methods to evaluate digital competency development.

4) Infrastructure and Resource Alignment – ensuring technological tools and connectivity support pedagogical objectives.

In conclusion, Disruptive change in education entails systemic transformation driven by technological innovation, globalization, and evolving socio-economic demands that reshape organizational and pedagogical structures. Digital transformation requires not only technology adoption but also structural and cultural adaptation, including agile governance and distributed leadership. educational leadership must integrate digital ecosystems across curriculum, assessment, and management while ensuring human capacity development and equity of access.

Transformative leadership in the digital era is adaptive, collaborative, and oriented toward continuous learning and shared responsibility. and strategic alignment between policy and classroom practice—through curriculum reform, pedagogical innovation, authentic assessment, and infrastructure support—is essential for sustainable enhancement of students' digital competencies.

Digital Competencies in Primary Schools

Digital competencies encompass technical, cognitive, and socio-emotional skills required for effective participation in a digital society (European Commission, 2018, p. 8). Students' digital competencies at the primary education level, grounded in the conceptual frameworks of the Office of the Basic Education Commission (2021), Ferrari (2013), UNESCO (2018), ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2019), UNICEF (2020), and Vuorikari et al. (2022), encompass six interrelated domains. These include: (1) information and data literacy; (2) communication and collaboration through digital technologies; (3) digital content creation and creative technology use; (4) digital safety and ethics; and (5) problem-solving and foundational computational thinking. Collectively, these competencies reflect a holistic framework for equipping primary students with the essential knowledge, skills, and dispositions required for effective participation in the digital age.

The key elements are as follows:

First, information and data literacy refers to the ability to access, select, analyze, and critically evaluate the credibility of information obtained from various digital

sources in an appropriate manner. ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2019: 22) and UNESCO (2018: 18) emphasize that information literacy constitutes a fundamental foundation for learning in the digital era and plays a crucial role in mitigating the risks associated with misinformation and inaccurate content.

Second, digital communication and collaboration involve the ability to use digital tools to communicate, exchange ideas, and work collaboratively with others in ways that are contextually appropriate and respectful. Ferrari (2013: 7) and UNICEF (2020: 29) note that this competency fosters social skills, teamwork, and constructive participation in digital society.

Third, digital content creation and creative use of technology refer to the ability to employ digital technologies to produce simple forms of content—such as text, images, audio, or multimedia—while considering appropriateness and copyright regulations. Vuorikari et al. (2022: 12) and the Office of the Basic Education Commission (2021: 18) indicate that this competency supports the development of learners' creativity and expressive potential in alignment with their individual capacities.

Fourth, digital safety and ethics encompass the ability to use technology safely, respect one's own rights and those of others, and recognize the ethical implications of digital media use. UNESCO (2018: 24) and UNICEF (2020: 35) underscore the importance of this competency in protecting children in online environments and fostering responsible digital citizenship.

Fifth, problem-solving and foundational computational thinking refer to the ability to apply systematic thinking processes, experimentation, and basic problem-solving strategies using digital tools. ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2019: 26) highlights that this competency strengthens logical reasoning skills and provides a foundation for more advanced learning in science and technology.

School Management Strategies to Promoting Digital competency in Primary Schools

Based on cross-analysis data synthesis and predictive validation procedures, the findings indicate that the effective development of digital competencies requires systemic alignment among leadership, curriculum, pedagogy, and institutional support structures. The analysis reveals that school management strategies aimed at promoting digital

competency consist of four interrelated components: (1) adaptive school management under disruptive change; (2) reform of academic administration to enhance students' digital competencies; (3) teacher capacity enhancement for digital competency development; and (4) the establishment of flexible and responsive learning support systems. Collectively, these strategic dimensions function as an integrated framework to ensure coherent, sustainable, and contextually responsive digital transformation in schools.

Each strategy encompasses the following key elements:

1. Adaptive School Management under Disruptive Change

Adaptive school management under disruptive change refers to a strategic and responsive approach to educational leadership that enables schools to navigate rapid technological advancement, shifting societal expectations, and increasing complexity in learning environments. In an era characterized by uncertainty and continuous transformation, school management can no longer rely on rigid structures or traditional administrative routines. Instead, it requires flexible governance systems, proactive decision-making, and a culture that encourages innovation and collaborative problem-solving. Adaptive management emphasizes the alignment of vision, policy, and practice, ensuring that organizational structures, academic processes, and resource allocation remain responsive to emerging challenges and opportunities. By fostering agility, shared leadership, and continuous improvement, adaptive school management strengthens institutional resilience and positions schools to sustain quality education while effectively preparing students for participation in a dynamic digital society.

Adaptive school management is central to enhancing digital competencies: Key elements include:

1) Strategic Vision and Digital Policy Alignment

School leaders must articulate a digital vision aligned with national policy frameworks such as Thailand 4.0 (NESDC, 2018, p. 52). Vision-setting enables coherence between curriculum, resource allocation, and assessment systems.

2) Distributed Leadership and Agile Governance

Distributed leadership fosters collaborative problem-solving and innovation (Fullan, 2014, p. 56). In Thai primary schools, forming digital task forces and professional learning communities enhances responsiveness to emerging technological demands.

3) Data-Driven Decision Making

Digital competency requires systematic monitoring of infrastructure usage, student competency progression, and teacher development. Data analytics inform strategic planning and resource prioritization.

2. Reforming Academic Administration to Promote Digital Competencies

Reforming academic administration to promote digital competencies requires a comprehensive and systematic transformation of curriculum design, instructional management, assessment practices, and resource allocation to ensure coherence and relevance in the digital era. Academic administration must move beyond traditional content delivery models toward an integrated framework in which digital competencies are embedded across subject areas and grade levels. This involves aligning curriculum standards with digital literacy, computational thinking, ethical technology use, and creative problem-solving skills, while encouraging interdisciplinary and project-based learning approaches. In addition, assessment systems should be redesigned to incorporate authentic, performance-based evaluations that capture students' ability to apply digital skills in real-world contexts. Effective reform also necessitates strategic planning in the allocation of technological infrastructure, learning platforms, and instructional resources to support pedagogical innovation. By establishing clear academic policies, monitoring implementation processes, and ensuring alignment between institutional goals and classroom practices, academic administration can serve as a driving force in systematically enhancing students' digital competencies and preparing them for meaningful participation in a rapidly evolving digital society.

Reforming Academic Administration to Promote Digital Competencies: Key elements include:

1) Curriculum Integration and Interdisciplinary Design

Academic administration must ensure digital competencies are embedded across subject domains rather than confined to ICT classes. Project-based and inquiry-based approaches strengthen higher-order digital skills.

2) Assessment Reform

Traditional examination systems often emphasize rote learning. Reform toward performance-based and digital portfolio assessments enables authentic evaluation of digital competencies (European Commission, 2018, p. 32).

3) Resource Allocation and Infrastructure Planning

Effective academic management prioritizes equitable distribution of digital tools and reliable internet access, particularly in rural Thai schools. Budget planning must align with pedagogical objectives rather than hardware acquisition alone.

3. Enhancing Teachers' Capacity for Digital Competency Development

Enhancing teachers' capacity for digital competency development is a critical dimension of sustainable educational transformation in the digital era. As key agents of instructional change, teachers must possess not only technical proficiency in using digital tools but also the pedagogical knowledge required to integrate technology meaningfully into teaching and learning processes. Capacity enhancement therefore involves continuous professional development that strengthens digital literacy, instructional design skills, classroom management in technology-rich environments, and the ability to facilitate student-centered, inquiry-based learning. Beyond formal training programs, supportive mechanisms such as mentoring systems, professional learning communities, peer collaboration, and reflective practice play an essential role in fostering confidence and innovation among teachers. School leadership must also create enabling conditions, including access to appropriate technological resources, time for collaborative planning, and a culture that encourages experimentation and continuous improvement. By systematically investing in teacher capacity building, schools can ensure that digital technologies are used not merely as supplementary tools but as transformative instruments for developing students' digital competencies in meaningful and sustainable ways.

Enhancing Teachers' Capacity for Digital Competency Development: Key elements include:

1) Professional Development Systems

Continuous professional development (CPD) is critical for digital pedagogy integration. Structured training programs combined with mentoring systems increase teacher confidence and instructional innovation (UNESCO, 2021, p. 41).

2) Digital Pedagogical Transformation

Teachers must shift from knowledge transmitters to facilitators of collaborative and technology-enhanced learning. Blended learning models and flipped classrooms support student-centered instruction.

3) Professional Learning Communities (PLCs)

PLCs enable peer coaching and shared reflection, reinforcing sustainable digital integration. In Thai schools, PLCs supported by OBEC policies have shown potential in scaling innovation at the school level.

4. Flexible and Responsive Learning Support Systems

Flexible and responsive learning support systems constitute a vital foundation for advancing digital competency development in contemporary education. In rapidly changing technological and social contexts, schools must establish support structures that are adaptable, student-centered, and capable of responding to diverse learning needs. Such systems integrate digital platforms, learning management systems, and interactive tools that facilitate personalized learning, real-time feedback, and continuous access to educational resources. Flexibility also involves designing hybrid and blended learning models that ensure continuity of instruction during disruptions while accommodating different learning styles and paces. Responsive support systems further encompass academic guidance, technical assistance, and inclusive measures that address equity and access, particularly for disadvantaged learners. By aligning technological infrastructure, instructional support, and learner services within a coherent framework, schools can create dynamic learning environments that not only sustain educational quality but also empower students to develop and apply digital competencies effectively in a rapidly evolving digital society.

Flexible and Responsive Learning Support Systems: Key elements include:

1) Learning Management Systems and Hybrid Models

Modern learning support systems include cloud-based platforms, learning management systems (LMS), and adaptive digital content. Hybrid models ensure continuity during crises and support differentiated instruction.

2) Community and Stakeholder Engagement

Collaboration with parents, local communities, and private-sector partners enhances digital competency. Public–private partnerships contribute technological expertise and funding support.

3) Equity and Inclusion Mechanisms

Responsive systems address digital divides by providing device loan programs and targeted support for disadvantaged learners. Equity-focused policies are essential for sustainable digital transformation.

Discussion

The case of Thai primary schools illustrates that digital competency is not merely technological but organizational. Adaptive management under disruptive change requires systemic alignment across leadership, curriculum, teacher capacity, and learning support systems.

Four strategic pillars emerge:

1) Adaptive leadership and governance reform

Adaptive leadership and governance reform emerge as foundational mechanisms in advancing digital competency development in primary schools under conditions of disruptive change. The findings of this study align with the broader literature indicating that digital transformation in education is not primarily a technological issue, but a leadership and governance challenge requiring systemic adaptation. Disruptive innovation theory suggests that organizations must undergo structural and cultural transformation to remain relevant in rapidly changing environments (Christensen, 1997, p. 102). In the context of primary education, this implies that school leaders must move beyond traditional bureaucratic models toward more agile and learning-oriented governance structures.

The results of the present case study reinforce the argument that adaptive leadership—characterized by flexibility, shared decision-making, and responsiveness to

uncertainty—is critical in steering digital reform. Fullan (2014, p. 27) emphasizes that effective school leadership in complex environments requires the capacity to mobilize collective efficacy and align institutional vision with instructional improvement. Similarly, Heifetz and Linsky (2002, p. 35) argue that adaptive leadership involves engaging stakeholders in addressing challenges for which no predetermined technical solutions exist, a condition that closely reflects digital transformation in primary education.

Governance reform, as observed in the participating schools, involved decentralizing decision-making processes, establishing digital task forces, and promoting professional learning communities to support innovation. This approach is consistent with research indicating that distributed leadership structures enhance organizational resilience and accelerate instructional change (Spillane, 2006, p. 12). By redistributing leadership roles, schools were able to integrate digital initiatives into curriculum planning, teacher development, and student assessment more coherently. These findings extend previous studies by demonstrating how distributed leadership structures operate in practice within primary school contexts facing digital disruption. While earlier research has emphasized the theoretical benefits of distributed leadership (Spillane, 2006), the present study provides empirical insight into how such governance arrangements enable the integration of digital competency development across multiple academic functions

Furthermore, the findings correspond with Organisation for Economic Co-operation and Development (OECD) (2019, p. 168), which highlights that system-level coherence—linking leadership, policy direction, and classroom practice—is essential for improving student competencies in the digital age. Adaptive governance enables schools to translate national digital education policies into context-sensitive strategies at the school level. In this respect, leadership serves as a mediating force between macro-level reform agendas and micro-level pedagogical implementation. Synthesizing these theoretical perspectives with the results of the present study suggests that adaptive leadership operates as the strategic driver that aligns institutional structures, professional collaboration, and digital learning goals.

In the Thai primary school context examined in this study, adaptive leadership contributed to clearer strategic direction, improved stakeholder collaboration, and more systematic integration of digital competencies across academic functions.

Governance reform was not limited to administrative restructuring but extended to cultural transformation, fostering openness to experimentation, data-informed decision-making, and continuous professional learning.

Taken together, the discussion suggests that adaptive leadership and governance reform are not peripheral components but central drivers of digital competency development. Sustainable digital transformation in primary education depends on leaders' capacity to cultivate institutional agility, align strategic vision with instructional practice, and build collaborative governance systems that can respond proactively to ongoing disruption.

2) Academic administration transformation

Academic administration transformation constitutes a central mechanism in advancing students' digital competencies under conditions of disruptive change. The findings of this study indicate that the effectiveness of digital competency development in primary schools depends largely on the extent to which academic management systems are strategically redesigned to align curriculum, pedagogy, assessment, and resource allocation with digital learning goals. This perspective is consistent with the view that sustainable educational reform requires coherence between leadership direction and instructional core processes (Fullan, 2014, p. 54). Without systematic transformation in academic administration, digital initiatives risk remaining fragmented or technology-centered rather than learning-centered.

The results further support the argument that curriculum integration is fundamental to digital transformation. Rather than confining digital skills to isolated ICT subjects, schools in this case study embedded digital competencies across disciplines through interdisciplinary projects and inquiry-based learning models. This approach aligns with the European Commission's DigComp framework, which emphasizes the cross-curricular integration of digital competence as a key condition for meaningful student development (European Commission, 2018, p. 32). Similarly, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2019, p. 174) highlights that education systems demonstrating higher levels of digital readiness are those that integrate digital literacy into mainstream curriculum standards rather than treating it as an ancillary skill. The transition toward digital portfolios and performance-based assessments observed in the

study reflects contemporary assessment theories emphasizing authentic evaluation of higher-order competencies. By aligning assessment practices with digital learning outcomes, the participating schools created stronger coherence between curriculum design and student competency development.

Assessment reform also emerged as a significant dimension of academic administration transformation. The participating schools gradually shifted from predominantly summative, paper-based examinations toward performance-based and digital portfolio assessments. Research suggests that authentic assessment practices better capture higher-order digital skills, including problem-solving, creativity, and collaborative competence (Redecker, 2017, p. 21). By aligning assessment methods with digital learning outcomes, schools reinforced instructional coherence and strengthened students' applied competencies.

In addition, strategic resource alignment played a critical role. The findings indicate that academic administration was most effective when technological infrastructure investments were guided by pedagogical priorities rather than hardware acquisition alone. This observation corresponds with UNESCO (2021, p. 41), which stresses that digital transformation efforts must prioritize instructional improvement and teacher support over mere technological expansion. When academic planning, budgeting, and monitoring systems were integrated, schools demonstrated greater consistency in implementing digital initiatives.

Within the context of Thai primary education, the transformation of academic administration served as a bridge between policy aspirations for digital advancement and classroom-level practice. By clarifying academic vision, redesigning curriculum structures, reforming assessment systems, and aligning resources with pedagogical innovation, schools were able to create systemic conditions conducive to sustained digital competency development.

Overall, the discussion underscores that academic administration transformation is not a peripheral adjustment but a structural reconfiguration of the instructional core. Effective digital competency development requires academic systems that are coherent, integrated, and strategically aligned with the demands of disruptive

change, thereby ensuring that digital learning becomes embedded in everyday teaching and learning practices rather than remaining an isolated reform initiative.

3) Teacher professional capacity enhancement

Teacher professional capacity enhancement represents a decisive factor in advancing students' digital competencies within the framework of school management strategies under disruptive change. The findings of this study indicate that digital transformation in primary schools cannot be sustained without systematic investment in teachers' digital knowledge, pedagogical skills, and adaptive mindsets. This conclusion is consistent with prior research emphasizing that teachers are the central mediators between technological innovation and student learning outcomes (ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), 2019, p. 186). Even when infrastructure and policy frameworks are well established, limited teacher capacity can significantly constrain the impact of digital reform initiatives.

The case study demonstrates that effective schools adopted continuous professional development (CPD) models that integrated technical training with pedagogical application. Rather than focusing solely on operational skills, professional learning activities emphasized instructional design, student-centered methodologies, and the integration of digital tools into inquiry-based and collaborative learning. This approach aligns with the European Framework for the Digital Competence of Educators (DigCompEdu), which highlights the importance of linking technological proficiency with pedagogical transformation (Redecker, 2017, p. 16). Similarly, UNESCO (2021, p. 43) underscores that teacher development programs must foster reflective practice and innovation to ensure meaningful digital integration. This integrated approach reflects contemporary theories of teacher professional learning that emphasize the relationship between technological knowledge, pedagogy, and content knowledge—often conceptualized through the Technological Pedagogical Content Knowledge (TPACK) framework.

Furthermore, the findings reveal that professional learning communities (PLCs) and peer collaboration mechanisms significantly strengthened teachers' confidence and instructional experimentation. Distributed and collaborative professional cultures enabled teachers to share best practices, address contextual challenges, and co-develop digital learning materials. This observation is supported by research suggesting that

collective efficacy and collaborative professionalism are critical drivers of sustainable school improvement (Fullan, 2014, p. 78). When teacher development is embedded within organizational learning structures, digital competency initiatives become more coherent and resilient.

The study also highlights the importance of leadership support in cultivating teacher capacity. School leaders who provided mentoring systems, allocated time for collaborative planning, and encouraged risk-taking created environments conducive to innovation. Spillane (2006, p. 13) argues that leadership practice is distributed across formal and informal actors within schools, reinforcing the notion that teacher empowerment enhances reform effectiveness. In the context of digital transformation, such distributed capacity-building fosters adaptive responses to rapidly evolving technological demands.

Within Thai primary schools, enhancing teacher professional capacity functioned as a bridging mechanism between strategic vision and classroom implementation. Teachers who demonstrated higher levels of digital pedagogical competence were more capable of integrating curriculum reform, authentic assessment, and differentiated instruction into daily practice. Consequently, students experienced more meaningful engagement with digital tools, leading to improved digital competency development.

Overall, the discussion affirms that teacher professional capacity enhancement is not merely supportive but foundational to digital transformation. Sustainable advancement of students' digital competencies depends on coherent professional development systems, collaborative learning cultures, and leadership practices that empower teachers as active agents of change in navigating disruptive educational environments.

4) Flexible and inclusive learning ecosystems

Flexible and inclusive learning ecosystems constitute a critical dimension of school management strategies aimed at enhancing digital competency under conditions of disruptive change. The findings of this study indicate that digital readiness in primary schools is significantly strengthened when learning environments are designed to be adaptable, technology-enabled, and responsive to diverse student needs. This perspective aligns with UNESCO's vision of education systems as dynamic ecosystems in which digital

technologies, institutional structures, and human actors interact to support equitable and lifelong learning (UNESCO, 2021, p. 19). Rather than viewing technology as a standalone intervention, schools that adopt an ecosystem approach integrate digital platforms, pedagogical practices, support services, and community partnerships into a coherent and mutually reinforcing framework.

The results further demonstrate that flexibility in learning delivery—through blended, hybrid, and platform-based models—enhances instructional continuity and personalization. ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2019, p. 170) notes that digitally mature systems are characterized by their capacity to adapt learning pathways to individual learner profiles while maintaining academic standards. In the primary school context examined, flexible scheduling, digital learning management systems, and interactive content allowed students to engage with materials at differentiated paces, thereby supporting varied learning styles and readiness levels. Such adaptability is particularly important in periods of disruption, where traditional face-to-face instruction may be interrupted. The case study illustrates that targeted support mechanisms—such as device access programs, technical assistance, and parental engagement—play a crucial role in reducing inequalities associated with the digital divide

Inclusivity also emerged as a foundational principle of effective digital ecosystems. The study found that schools which implemented targeted support mechanisms—such as device loan programs, technical assistance, and parental engagement initiatives—were better able to mitigate inequities associated with the digital divide. Research by UNICEF (2020, p. 35) emphasizes that equitable access to digital resources is essential for safeguarding children's rights and ensuring meaningful participation in digital learning environments. Similarly, UNESCO (2018, p. 24) underscores the importance of inclusive digital policies that address disparities in connectivity, digital literacy, and socio-economic status.

Moreover, the ecosystem perspective highlights the interconnectedness of leadership, infrastructure, teacher capacity, and student engagement. Fullan (2014, p. 89) argues that sustainable educational change occurs when systemic alignment reinforces instructional improvement at scale. In this study, flexible and inclusive learning ecosystems

functioned as enabling structures that translated strategic leadership and academic reform into accessible and supportive learning experiences for students. When technological infrastructure, instructional design, and student support services operated cohesively, digital competency development became embedded in everyday practice rather than treated as an isolated initiative.

In the Thai primary school context, the establishment of flexible and inclusive learning ecosystems strengthened institutional resilience and promoted broader participation in digitally mediated learning. By ensuring adaptability, accessibility, and coordinated support, schools were able to create environments that not only sustained educational quality during disruption but also advanced students' digital competencies in an equitable and sustainable manner. Overall, the findings affirm that flexible and inclusive ecosystems are indispensable to effective school management strategies in the digital age, serving as the structural foundation for inclusive and future-oriented learning transformation.

Conclusion

The twenty-first century is characterized by rapid digital transformation that has profoundly reshaped educational systems worldwide. Technological innovation has altered learning environments, required competencies, and institutional governance structures, while the COVID-19 pandemic further accelerated digital adoption and exposed structural inequities and limitations in traditional school management models. Within this context, primary education holds a crucial role in laying the foundation for lifelong learning, adaptability, and responsible digital citizenship. Consequently, school administration must move beyond conventional bureaucratic approaches and adopt adaptive management models capable of responding to continuous technological and societal change.

In Thailand, national reform agendas, including the 20-Year National Strategy and the Thailand 4.0 policy, emphasize the development of human capital and digital capabilities. Despite these strategic directions, many primary schools—particularly those under the Office of the Basic Education Commission—continue to face significant challenges related to digital infrastructure, teacher preparedness, and leadership

adaptability. Policy initiatives by educational authorities have encouraged the integration of digital technologies into teaching, learning, and school administration; however, the effectiveness of these reforms ultimately depends on how school leaders interpret and implement them within specific institutional contexts.

Scholarly perspectives on disruptive innovation highlight that meaningful digital transformation requires not only technological adoption but also structural and cultural adaptation within educational organizations. Effective leadership in such environments involves adaptive, collaborative, and distributed governance capable of mobilizing stakeholders and fostering innovation. Strategic alignment between policy direction and classroom implementation therefore becomes essential. In particular, strategies that integrate curriculum reform, pedagogical innovation, assessment transformation, and infrastructure development are critical to strengthening students' digital competencies.

Digital competencies in primary education encompass a broad set of technical, cognitive, and socio-emotional skills required for effective participation in digital society. These include information and data literacy, digital communication and collaboration, digital content creation, digital safety and ethical awareness, and problem-solving supported by foundational computational thinking. Together, these competencies form a holistic framework that enables young learners to engage critically, creatively, and responsibly with digital technologies.

The analysis further indicates that promoting digital competency requires coherent school management strategies that align leadership, academic administration, teacher capacity, and learning support systems. Four strategic dimensions emerge as particularly significant: adaptive school management under disruptive change, transformation of academic administration to integrate digital competencies across the curriculum, systematic enhancement of teachers' professional capacity in digital pedagogy, and the establishment of flexible and inclusive learning ecosystems. When these elements operate in an integrated and coordinated manner, schools are better positioned to translate national policy aspirations into sustainable classroom practices.

Overall, the findings suggest that digital competency development in primary education is not merely a technological issue but a systemic organizational challenge. Sustainable digital transformation depends on adaptive leadership, coherent academic

governance, empowered teachers, and supportive learning environments that ensure equitable access and meaningful participation. Through strategic alignment across these dimensions, schools can effectively prepare students with the competencies necessary to thrive in an increasingly complex and digitally mediated world

Digital competency in Thai primary schools under disruptive change necessitates integrated school management strategies. Adaptive leadership, curriculum reform, teacher capacity building, and responsive learning systems must function synergistically. Policymakers and school leaders should prioritize systemic coherence and sustainable innovation to ensure that digital competencies become foundational outcomes of primary education in Thailand.

Future studies would contribute to a deeper understanding of effective digital education reform and provide practical guidance for policymakers and school leaders seeking to strengthen digital readiness in primary education.

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Enhancing the Quality of Life for Thai Elderly through Tourism: Insights from the Private Sector

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Abstract

As Thailand transitions into a complete aged society, improving the quality of life for seniors has become a key socio-economic priority. Tourism stands out as a powerful tool for promoting comprehensive well-being in this demographic. This research article aims to analyze the tourism models developed by the private sector to enhance the quality of life for the elderly, and to propose guidelines for sustainable senior tourism development from a private-sector perspective. This qualitative study gathered data from documents, publications, and websites, as well as interviews with eight entrepreneurs, tour guides, and tour leaders who operate businesses related to or specifically serve elderly travelers. The data was subsequently subjected to content analysis through the researchers' perspective.

The research findings indicate that private sector entrepreneurs play a vital role in designing activities and services that promote the physical, mental, and social well-being of the elderly, with a primary focus on safety and age-appropriate experiences. However, the costs associated with both private and group tours vary significantly. This cost factor may act as a major barrier to tourism access for the Thai elderly. Consequently, a multi-stakeholder collaboration involving government agencies, the private sector, independent organizations, and local communities is essential to ensure long-term continuity and sustainability. In conclusion, the CHAN Model—comprising Cultural, Health, Soft Adventure, and Nature tourism—is proposed as an integrative framework to strengthen and standardize the Thai senior tourism sector. Briefly, cultural tourism helps boost cognitive and mental stimulation, social integration and reduced isolation, and sense of purpose and self-worth. Health tourism raises physical rejuvenation and pain management, mental health and stress reduction, and empowerment and autonomy. While soft adventure tourism lifts physical vitality and functional mobility, nature tourism

uplifts psychological restoration and sensory stimulation. If these four tourism sectors are well-integrated, they create a "quadruple-win" scenario.

Keywords: Quality of life development for the elderly, Tourism, Private stakeholders

Background and Statement of the problem

Since 2004, when Thailand first transitioned into an aging society with an elderly population of 4,281,681, the country has progressed into a complete aged society. Currently, the number of elderly citizens has reached 9,307,575 out of a total population of 64,953,635. This represents 14.33% of the total population (Department of Provincial Administration, Ministry of Interior, 2026). As Thailand's elderly population continues to rise steadily (Figure 1), enhancing the quality of life for seniors has become a critical priority in policy-making and social development. Promoting Active Aging is no longer limited to healthcare or social welfare; it must also encompass participation in economic, social, and cultural activities which serves as a fundamental conceptual framework for aging policy development across numerous countries (WHO, 2002).

Despite Thailand's continuous expansion of welfare and geriatric healthcare measures—such as the age-tiered living allowance and the 'Universal Coverage Scheme' (Gold Card) providing free medical services—these initiatives remain largely rooted in a care-based approach. While essential, such reactive strategies may be insufficient for the long-term enhancement of the quality of life for the Thai elderly population. In light of these challenges, it is essential to prioritize initiatives that encourage social participation and the creation of meaningful life experiences for the elderly. Existing research indicates that participation in social and recreational activities is positively correlated with higher life satisfaction levels and serves as a significant diminishing factor against the risk of depression among the elderly. As a multifaceted activity, tourism has the potential to boost senior quality of life and active aging by integrating relaxation, education, social engagement, and wellness (Qiao, G. and et.al., 2022; Sedgley, D. and et.al., 2011).

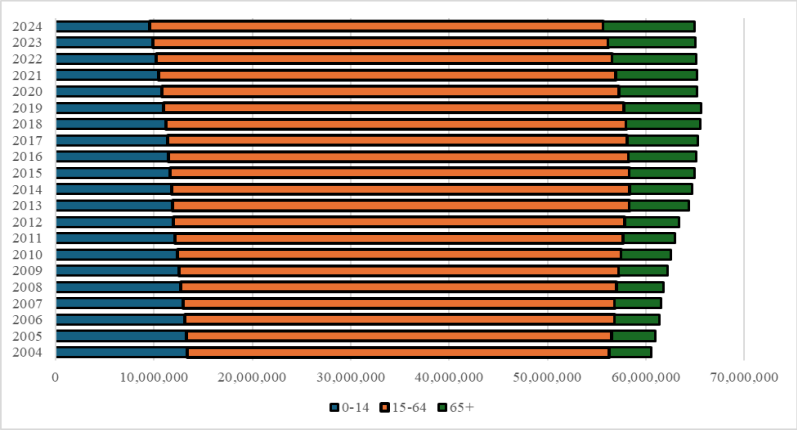


Figure 1 Population Demographics Across Three Age Groups (Children 0–14, Working Age 15–64, and Seniors 65+) during 2004–2024

Note: From "Official statistics registration systems" by Department of Provincial Administration, Ministry of Interior, 2026

Therefore, elderly tourism represents more than simple relaxation; it functions as a proactive driver of Active Aging, contributing significantly to the well-being of the older population. Research by Kim, Woo, and Uysal (2015) demonstrates that travel experiences have a direct impact on the life satisfaction and personal well-being of older adults. Furthermore, the Wellness Tourism framework proposed by Mueller and Kaufmann (2001) suggests that tourism can serve as a vital instrument for promoting both physical and mental health, particularly among populations requiring preventive care.

In preparation for the coming years, Thailand is inevitably transitioning into a Super-aged Society, where the population aged 65 and over will exceed 20%. This shift will impact various social systems, including healthcare, medical services, the economy, and tourism. It presents a new challenge for all sectors — particularly the private sector. Tourism entrepreneurs must prepare and develop specific strategies for senior tourism to ensure a comprehensive and holistic approach to serving Thailand's elderly travelers.

Hence, it is essential to expand the conceptual framework from 'Economic Tourism' toward 'Tourism for Active Aging.' In this paradigm, the private tourism sector develops beyond its role in revenue generation and consumption to function as a social mechanism for enhancing the quality of life for the elderly. By developing products and services tailored to the physical and psychological capacities of older adults, the industry can effectively mitigate social isolation, foster engagement, and cultivate a sense of

purpose. At the macro level, the Silver Economy concept—supported by the Organisation for Economic Co-operation and Development (OECD, 2014)—identifies the aging population as a significant economic force capable of driving the second and third demographic dividends. Developing specialized sectors like senior-centric tourism is therefore essential for creating dual economic and social value. Aligning the quality of life of older adults with national economic drivers represents a key strategic move for sustainable development.

Objective

1. To analyze the tourism models developed by the private sector to promote the quality of life for the elderly.
2. To propose a roadmap for sustainable senior tourism from a private-sector perspective.

Expected benefits

1. To upgrade the standards for designing and planning tourism models that promote elderly well-being, while generating business growth opportunities in the senior market and ensuring the sustainability of the tourism sector.
2. To benefit government and private organizations related to elderly tourism and contribute to the advancement of educational programs and academic research in related fields.

Conceptual Framework

The Concept of Senior Quality of Life (QoL) and Active Aging

The World Health Organization (WHO, 2002) defines the elderly as individuals aged 60 years and older. Furthermore, the WHO categorizes this population into three subgroups: the Elderly (aged 60–74), the Old (aged 75–90), and the Very Old (aged 90 and above). Conversely, in developed regions such as Europe and North America, and in accordance with the United Nations (UN) definition, individuals aged 65 and over are classified as elderly. The quality of life for the elderly is a multidimensional concept encompassing physical, psychological, social, and environmental dimensions. Key components that define their quality of life include maintaining good health, achieving

life satisfaction, engaging in social interactions, and fulfilling meaningful roles within society.

The concept of Active Aging is a framework developed by the World Health Organization (WHO) that aims to promote the holistic well-being of the elderly — encompassing physical, mental, and intellectual health. It encourages social participation and a high quality of life to enable seniors to remain self-reliant for as long as possible. This is a rights-based approach, asserting that elderly individuals are entitled to these fundamental standards. The framework consists of three key pillars: (1) Health, (2) Security, and (3) Participation (WHO, 2002).

Concepts of Senior Tourism

Senior Tourism refers to itineraries specifically designed with activities, services, and facilities that align with the unique limitations and needs of older adults. The travel patterns and behaviors characteristic of retirees and senior tourists prioritize high-quality, age-appropriate experiences where value for money is a key consideration. Furthermore, this segment relies heavily on safety standards, reliable service, and comprehensive health and wellness care. Ideal destinations for senior tourists are those that offer easy accessibility, are located within close proximity to urban centers, and provide appropriate facilities and amenities (Korawan Sangkakorn and et.al., 2012).

Despite being regarded as a high-potential market with strong spending power, seniors exhibit distinct differences in their travel patterns and how they make travel decisions (Sangpikul, 2008; Littrell et al., 2004).

Strategic Advancement of the Senior Tourist Market

As provided by United Nations (2022), by 2050, it is expected that one in six people will be over 65 years old. The surge in the older population has gained significant interest within the tourism sector worldwide. Happiness can be defined as desirability, considering external criteria, such as virtue or holiness. Highly social activities like leisure and tourism are considered to have positive effects on the elderly's mental health. The tourism experience facilitates healthy aging through three primary dimensions: physical revitalization via nature-based tourism; emotional well-being fostered by social engagement with peers, relatives, and local communities; and spiritual enrichment derived from transcendent travel experiences. (Chen, S. and et.al., 2026)

The contemporary tourism landscape is characterized by a growing interest in niche segments, specifically educational and soft adventure tourism, alongside an emphasis on cultural heritage and volunteering-based travel (Camara, E. and et.al., 2024). Social engagement serves as a critical determinant of well-being in later life, acting as a primary buffer against depression and social isolation. Within the tourism sector, Destination Management Organizations (DMOs) are increasingly tasked with arranging 'memorable experiences' that highlight physical health benefits, particularly through interventions situated in natural environments. (Patterson & Balderas-Cejudo, 2023)

Role of the Private Sector in Tourism

In Thailand, the travel business refers to the organization of activities or services related to taking tourists to various destinations, both domestically and internationally. This includes providing facilities such as accommodation, meals, tour programs, and guide services. These operations are primarily conducted by the private sector. Furthermore, such businesses are regulated by the Department of Tourism, Ministry of Tourism and Sports, under the Travel Business and Guide Act, B.E. 2551. Operating without a license is considered illegal and subject to penalties, including the permanent revocation of the right to apply for a license in the future (Department of Tourism, Ministry of Tourism and Sports, 2026).

Hence, the private sector is the main driver in developing tourism offerings, especially in the design of wellness, cultural, and experiential travel models. Furthermore, the flexibility and adaptability of the private sector enable it to respond effectively to the demands of the elderly demographic.

Research Methodology

This study employs a qualitative research methodology, utilizing secondary data from documents, research papers, publications, and various websites related to elderly tourism and the role of the private sector both nationally and internationally. Additionally, in-depth interviews were conducted with eight participants, including business operators, tour guides, and tour leaders. The participants were selected through purposive sampling based on specific criteria: they must operate a business related to elderly tourism or

have direct experience providing services specifically for seniors, and they must have at least five years of professional or business experience in the field.

Moreover, the study used semi-structured interviews covering four primary themes: (1) perspectives and experiences in senior tourism; (2) specifically designed activity patterns and services; (3) observed impacts on the quality of life of the elderly; and (4) challenges, obstacles, and policy recommendations. Data obtained from interviews and other sources were compiled and subjected to content analysis from the researchers' perspective. The data were categorized according to primary points and presented as key themes.

Research Results

The data obtained from interviews with a total of eight participants—comprising business operators, tour guides, and tour leaders—can be categorized into the following four primary themes:

1) Perspectives and experiences in senior tourism: Informants noted an increasing trend among Thai senior travelers. This insight was largely gained through their experience guiding tours in Thailand and developed countries, especially in Europe. Consequently, this has driven a significant interest in targeting the senior traveler segment. Regarding the business operators, it was found that there has been a significant increase in senior groups requesting tour services over the past ten years. This has led to the implementation of targeted marketing strategies for the elderly segment, such as public relations efforts specifically branding tours as 'senior-only' and offering specialized promotions. Besides, these companies have selected strategic partners and suppliers who also prioritize the elderly market. On average, the sampled private sectors have been operating under these principles for approximately eight years.

"I have experienced two types of tours for seniors over 60: private group bookings with their own age group, and joining mixed groups with other travelers."

(Tour operator 2)

"I have experience organizing temple tours that include merit-making and the symbolic release of animals to save them from slaughter."

(Tour guide 1)

2) Specifically designed activity patterns and services for the elderly: Because the elderly differ significantly from other age groups, the core principle of caring for and serving this demographic is a heightened attention to detail. For example, domestic tour programs combine sightseeing with wellness-enhancing activities, such as visiting national parks paired with hot spring bathing, or visiting hill-tribe handicraft groups followed by local cooking classes. Not only that, daily itineraries are planned to minimize travel time, typically including visits to two attractions and one activity per day. However, the data indicates that tourism patterns for the elderly must prioritize safety and comfort. In addition, if tour guides possess knowledge or have undergone training in first aid and psychology, it significantly enhances the confidence and trust of the service users.

> *"Designing tour programs for older adults requires a primary focus on their physical and psychological capacities. Accommodation must feature appropriate accessibility, such as elevators, low-rise buildings, or minimized walking distances, to ensure both convenience and safety. Nutritional services must prioritize hygiene and incorporate pre-screened data regarding food allergies. Furthermore, tourism activities and site selection must be centered on risk mitigation, while transportation should offer high levels of comfort and emergency restroom facilities. Regardless of the destination type, safety remains the overarching priority."*
>
> (Tour guide 3)

> *"The duration of travel for distant destinations is a critical factor in senior tour planning. High-altitude terrain and stairs present both time-management obstacles and heightened safety risks for elderly participants. Due to limited physical issues, packed single-day programs result in "cumulative fatigue," where the impact of overactivity is felt more distressingly in the following days than in average tourists."*
>
> (Tour operator 4)

3) Observed impacts on the quality of life of the elderly: It was found that the majority of elderly travelers are highly active and energetic, demonstrating a strong desire for independence and self-reliance. They appear cheerful and enjoy a satisfying experience. Many clients become repeat customers and actively refer new customers, leading to a growing customer base.

"From my observations, some clients have so much fun they forget they're even tired. Some might struggle to walk on the first day, but by the second, they're walking faster than the guide! The customers really love it; they tell me that every single time."

(Tour guide 2)

"Our company has focused on senior tour programs for a long time, and the feedback has been excellent. Some Subdistrict Administrative Organizations (SAO) even hire us specifically to organize trips for their elderly residents. We've been doing this for two consecutive years now, and their evaluations always come back with high praise."

(Tour operator 1)

4) Challenges, obstacles, and policy recommendations: Research findings indicate that specialized facilities—such as elderly-friendly buses, vans equipped with ramps, or extra-soft seating—result in higher tour program costs. This factor may serve as a significant barrier to access for Thai elderly tourists. Nonetheless, maintaining high standards for assistive equipment remains essential. Regarding accommodation, attractions, and various service points, current infrastructure is relatively supportive and well-suited for senior tourism. Also, there is a relatively limited workforce specializing in elderly tourism. While there are personnel who understand senior needs or have undergone geriatric care training, a significant labor shortage occurs during peak tourism seasons. This scarcity of qualified professionals poses a major challenge to the industry's growth.

"Key obstacles in senior tourism involve participants withholding critical health data and risk disclosures. Additionally, environmental and logistical factors beyond the organizers' control—including weather, traffic, and third-party service quality—pose risks to the overall execution and safety of the tour."

(Tour guide 3)

"Uncontrollable environmental variables, such as unpredictable weather, can be mitigated through early forecasting and preventative measures. Logistical challenges specific to elderly travelers—including forgetfulness (e.g., medication) and physiological needs (e.g., frequent or prolonged restroom use)—require a slow-paced itinerary that allows for sufficient time at each destination. Service delivery must be efficient and emotionally supportive; it is critical to avoid conflict or insensitive language that may cause emotional distress. While travel obstacles are inevitable, proactive planning can minimize their impact.

Finally, immediate access to emergency medical facilities throughout the journey is essential for rapid intervention"

(Tour operator 2)

Summary of the Study

Elderly tourism is an activity that aligns with the concept of quality of life for seniors meaning that participation in social activities and appropriate leisure can enhance overall well-being. As the result, the private sector in the tourism industry does not only play an economic role but also serves a social function in increasing the quality of life for the Thai elderly population.

The private sector has placed increasing importance on the development of elderly tourism, driven by a steady rise in market demand. Tourism is viewed not merely as a leisure activity anymore, but as a vital instrument for physical and psychological rehabilitation. Consequently, tourism models aimed at enhancing the quality of life for seniors should focus on wellness tourism that provides both physical and mental well-being—such as Thai traditional massage and health rehabilitation programs. Furthermore, cultural tourism that emphasizes learning about local ways of life and traditional wisdom should be integrated, as these experiences contribute significantly to the physical and mental health of the elderly.

Regarding the guidelines for sustainable elderly tourism development from a private sector perspective, two key areas are identified: (1) Service Design and Infrastructure: The private sector is actively enhancing facilities to accommodate the elderly. Examples include scheduling fewer daily activities, prioritizing low-impact movements, and ensuring strict safety standards during transportation. This also includes providing accessible accommodation featuring ramps and safety-compliant bathrooms. (2) Social and Economic Value Creation: Senior tourism fosters social participation and reduces feelings of isolation. Additionally, it generates revenue for local communities, creating a positive impact on both the well-being of the elderly and the broader economic system

Discussions

The research findings align with the World Health Organization's (WHO) Active Aging framework across five key dimensions, as follows:

1) Psychological Well-being and Self-Esteem: The study reveals that travel experiences play a crucial role in relieving depressive symptoms. The tourism industry is responding by developing lifelong learning initiatives that encourage seniors to explore new interests. By facilitating social interaction, these programs combat the sense of social isolation often felt by the elderly. These observations support (Ratanapaitoonchai, 2014) conclusion that outdoor leisure activities are vital for triggering the release of 'happiness' neurotransmitters.

2) Universal Design and Infrastructure: Insights from industry stakeholders reveal that infrastructure is the 'make-or-break' factor for elderly well-being. By reconstructing facilities with Universal Design features like accessibility ramps and grab bars, businesses provide more than security—they empower seniors with functional autonomy. This independence is recognized as a primary benchmark for a high quality of life.

3) Impact of the Silver Economy: Private sector perspectives identify the elderly as a high-potential segment characterized by significant purchasing power and extensive leisure time. In Thailand, the cultural status of the elderly as the 'pillars of the home' means their preferences often drive family spending. By expanding Wellness Tourism through offerings like regional superfoods and medical-leisure packages, the industry can stimulate community-based economic growth. This strategy upgrades industry standards and shifts the market toward a more inclusive, family-oriented travel model.

4) Responsibility and Safety: The private sector identifies trust as the primary driver of service excellence. Utilizing guides with Elderly Care Training effectively reduces stress for both seniors and their relatives. Ultimately, these safety-first initiatives are directly linked to improved life satisfaction, reinforcing the social value of specialized tourism services.

5) TravelTech: As technology adoption grows among the elderly, the private sector has an opportunity to provide accessible digital platforms. Booking applications that prioritize ease of use help seniors maintain their independence and self-reliance.

This technological empowerment is essential for ensuring that older adults feel capable and autonomous in their travel trails.

Tourism facilitates social engagement, reducing isolation and improving self-worth for seniors. This finding aligns with the Successful Aging framework proposed by Rowe and Kahn (1997), which posits that maintaining high levels of social engagement and meaningful social roles is a fundamental component of aging successfully." Rather than being mere 'consumers,' elderly travelers act as 'participants' in social and cultural exchanges. Group travel with peers, cultural immersion, and nature-based activities all foster social engagement, which yields positive effects on psychological well-being. This is corroborated by the research of Kim, Woo, and Uysal (2015), which confirms that meaningful travel experiences significantly impact long-term life satisfaction and subjective well-being. Consequently, it is imperative to design senior tourism initiatives that prioritize appropriate and meaningful participation.

The tourism industry acts as more than just a financial driver; it is a vital social tool for promoting senior well-being. A critical finding of this study is that tourism can cultivate a 'sense of life meaning' for older adults, which aligns with the Japanese concept of Ikigai. The work of Akihiro Hasegawa (2003) supports this, indicating that seniors who possess a sense of Ikigai exhibit significantly lower levels of depression and higher overall life satisfaction. Thoughtfully designed tourism, including cultural learning and life-reflection programs, empowers seniors to perceive their own worth and contribution to society. These observations corroborate the research of Michiko Kumano (2018), which suggests that a sense of purpose (Ikigai) emerges through maintaining social roles and engaging in activities that carry personal significance.

Enhancing the quality of life for the elderly alongside driving the economy through domestic tourism is a key policy in many countries. For instance, in Japan, private sector providers offer comprehensive services specifically for the senior demographic. A notable example is Japanet Takata Co., Ltd., which offers specialized 10–12 day cruise programs around the Japanese islands. These cruises provide sightseeing experiences and activities designed to promote both physical and mental health. All Japan Tours offers specialized group travel services tailored specifically for seniors, featuring custom-designed coaches that prioritize safety and comfort. These vehicles are equipped with spacious seating and

individualized climate control systems. The vehicles also support assistant installations, such as wheelchair-accessible boarding systems, to meet the specific requirements of the elderly demographic. This approach produces a high quality of life and cultivates 'Ikigai'—a sense of purpose—enabling the elderly to recognize their own self-worth. (Japanet Takata, 2026)

This research links the concept of Active Aging (WHO, 2002) with senior tourism frameworks to establish a clear standard for Thai elderly tourism, namely the CHAN Model. The details of this model can be summarized as follows: C stands for Cultural Tourism which promotes the spiritual and social well-being of the elderly. Stepping out of a daily routine to navigate new environments builds confidence. H stands for Health Tourism which promotes the physical and mental well-being of the elderly. It often includes personalized dietary plans. This can be further integrated into Wellness-Oriented Cultural Tourism on an international scale, or to take care of foreign senior tourists in the future. A stands for Soft Adventure Tourism which refers to a pattern of activities that promotes mobility or consists of low-impact activities that are beneficial to the elderly. Unlike traditional tours, it usually takes place in remote or natural settings to create highly intensive social bonds. And N stands for Nature Tourism which puts emphasis on nature by applying the 'Forest Bathing' concept tailored for the elderly demographic. Nature acts as a powerful social balancer; meanwhile, nature tourism encourages movement without the "clinical" feel of a gym. (Figure 2)

The practice of Forest Bathing (Shinrin-Yoku) has transitioned from an 1980s Japanese wellness tradition into a significant focal point for medical and therapeutic tourism. Current research suggests that by immersing oneself in forest environments through multisensory engagement, individuals can get benefit from the forest's restorative properties. This process doesn't just promote relaxation; it may actively manage chronic conditions like hypertension by simultaneously reducing psychological stress and optimizing autonomic nervous system responses. (Li, A. and et.al., 2025) While hiking is often goal-oriented, forest bathing prioritizes the 'here and now' through sensory awareness, making it a unique tool for boosting immune function and mental clarity. Because the needs of older adults are different, forest environments must be designed with flexibility in mind to accommodate varying functional abilities. By prioritizing

accessibility, these spaces are transformed into inclusive hubs for active aging, ensuring that the psychological benefits of nature are available to everyone, regardless of physical constraints. (Spiegel, Y. and et.al., 2025)

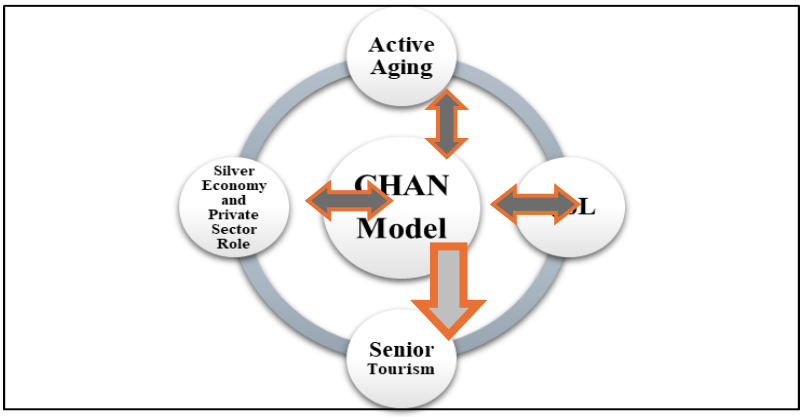


Figure 2 CHAN Model

Note: From Researcher, 2026

If CHAN model is well-managed, it creates a "quadruple-win" scenario: (1) elderly tourists foster active aging, (2) private stakeholders achieve sustainable profitability, (3) local culture and the economy are revitalized, and (4) the public sector reduces the healthcare burden.

Recommendations

The recommendations for this research can be divided into two parts: (1) Policy and Practical Recommendations, and (2) Recommendations for future research. Regarding the policy recommendations, there should be coordinated cooperation among the public sector, the private sector, and local communities to develop creative and elderly-friendly tourism models. It is essential to establish common standards that are easily applied to the specific context of each area. For example, there should be a development of curricula or knowledge bases concerning basic first aid and geriatric psychology, in which relevant public health and medical agencies should actively participate. A collaborative consortium between the hospitality and medical sectors is recommended to repurpose hotels as Wellness & Recovery Hubs. By integrating the unique strengths of both industries,

this partnership transforms hospitality into a space dedicated to preventive care and rehabilitation.

The establishment of senior tourism standards for human resource development should be considered to ensure personnel possess the necessary expertise in elderly care. Under this partnership, hotel staff will undergo specialized training provided by partner hospitals. Additionally, a direct emergency communication channel with medical teams will be established to ensure immediate response. Dining and wellness programs are developed by medical experts. By utilizing nutritionists and physical therapists from partner hospitals, hotels can provide customized wellness regimes that are both safe and effective for diverse guest profiles. This includes creating safety protocols and ensuring fair, equitable access to all available services.

While Universal Design promotes inclusivity, the high cost of implementation remains a barrier. Improving existing facilities to be 'senior-friendly' requires significant investment. From installing elevators to non-slip floor treatments, the costs are substantial, yet these modifications rarely produce a direct return on investment (ROI) in the near future. Government intervention is essential to share the financial load and ensure these accessibility standards are adopted nationwide. The government should implement tax incentives to encourage immediate action. For instance, allowing businesses to claim a double tax deduction (e.g., 200% of the actual expenditure) on renovation costs would significantly lower the barrier for entrepreneurs to invest in these improvements.

Regarding recommendations for future research, empirical studies should be encouraged to examine the long-term effects of tourism on the quality of life of the Thai elderly. Additionally, as data from the private sector provides vital insights that help clarify management and development strategies, future studies could expand into quantitative research or apply the models developed in this study to different subgroups of seniors based on their specific stages of aging. Likewise, to strengthen the theoretical framework, future research should implement impact-measurement tools for tourist quality of life. By conducting pre- and post-activity assessments, researchers can generate stronger evidence for the benefits of inclusive travel. Furthermore, the CHAN Model should be tested across diverse geographical areas and demographics to enhance its generalizability and validity.

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Challenges Faced by Older Workers in Thailand: Age Discrimination and Its Economic Impact

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Abstract

Thailand is facing significant demographic changes, with a growing aging population due to lower fertility rates and longer life expectancy. This paper examines the challenges that older workers in Thailand's labor market encounter, particularly focusing on age discrimination and its economic consequences. Despite existing legal protections against age-based discrimination, many older workers, especially those aged 65 and above, continue to face barriers in securing stable and well-paying jobs. These barriers include age-related biases regarding their adaptability, technological skills, and productivity. As the working-age population shrinks, older workers are often pushed into informal, low-wage sectors that lack adequate social protection, increasing economic inequality. Moreover, limited access to retraining and skills development opportunities, particularly in rural areas, makes it harder for older workers to adapt to the demands of modern industries. The economic impact of this exclusion is severe, as it contributes to reduced labor force participation, social marginalization, and greater financial insecurity. To address these challenges, the paper advocates comprehensive policy reforms that focus on reducing age discrimination, expanding social protection, and investing in skills training and career support for older workers. By creating a more inclusive workforce, Thailand can ensure that older workers remain valuable contributors to the economy, even in the face of demographic and technological shifts.

Keywords: Age Discrimination, Older Workers, Labor Markets, Economic Impacts.

Introduction

Thailand is experiencing a significant demographic shift, with a growing aging population due to a decline in fertility rates and increased life expectancy. As a result, the proportion of older workers in the labor force is rising, which presents both challenges and opportunities for the economy. However, older workers in Thailand face considerable obstacles in the labor market, particularly due to age discrimination. Despite the presence of legal protections, many older individuals struggle to secure stable and well-paying jobs due to biases regarding their adaptability, technological skills, and productivity.

Older workers are often pushed into informal sectors, where job security is low, and wages are minimal, making it difficult for them to achieve financial stability. This exclusion not only increases economic inequality but also isolates many older workers from the benefits of a rapidly evolving labor market. The rise of knowledge-based industries and technological advancements has only further marginalized those who lack digital literacy or access to retraining programs, especially in rural areas.

This paper explores the various challenges faced by older workers in Thailand, focusing on the impact of age discrimination on their economic well-being and their ability to participate meaningfully in the labor market. By examining demographic trends, social attitudes, and labor market dynamics, the paper highlights the need for comprehensive policy reforms to address these issues and ensure that older workers remain active contributors to the economy.

Content

To understand, the demographic and economic context is essential for analyzing the impact of age discrimination on older workers in Thailand's labor market. Thailand is experiencing significant demographic shifts, particularly an aging population due to declining fertility rates and increased life expectancy. According to the World Bank (2025), approximately 13% of the population was aged 65 and older as of 2020, with projections indicating this figure will rise to 31% by 2060. This demographic transition presents both challenges and opportunities for the labor market, particularly in terms of labor force participation among older workers. The decline in fertility rates, from 5.5

children per woman in 1970 to 1.5 in 2020 (Moroz and Naddeo, 2025), has been accompanied by rising life expectancy, leading to an older population that remains economically active for longer. As a result, Thailand faces a shift in its labor force demographics, which directly impacts labor market dynamics, especially for older workers. The economic implications of this aging population are multifaceted. As the working-age population shrinks, Thailand may face a potential labor shortage, which could hinder economic growth. The World Bank (2025) predicts that Thailand's working-age population will decrease by nearly 30% between 2020 and 2060, placing significant pressure on the country's economic growth. Labor force participation rates among older workers, particularly those aged 65 and older, are notably lower than their younger counterparts, especially compared to other East Asia and Pacific countries such as Cambodia and Indonesia (International Labour Organization, 2025). Structural and cultural factors contribute to this, with older workers often excluded from higher-paying and stable jobs due to biases around age and productivity. Many older workers are relegated to informal, lower-wage sectors, where job stability and social protections are minimal. Zaniboni (2015) found that this economic vulnerability, particularly for older workers in rural areas, stems from insufficient social protection, lack of pension schemes, and limited retirement savings. Income inequality among older workers is further exacerbated by both age discrimination and broader economic inequalities. The increasing competitiveness and technological drive of the labor market often leave older workers, especially those aged 60 and above, excluded from higher-paying opportunities. Blau (2025) suggests that older women face a "double disadvantage" due to both age and gender biases, which significantly heightens economic challenges for them. Social protection programs like the Old Age Allowance have been introduced, but they remain insufficient for addressing the financial needs of older workers, particularly those in informal jobs. This lack of adequate support forces many older workers to remain economically dependent, perpetuating a cycle of poverty and economic exclusion. Moroz and Naddeo (2025) also point out that older workers in rural regions face disproportionate economic inequality due to the dual nature of Thailand's labor market, with many unable to keep pace with modern, knowledge-based industries.Social exclusion and marginalization of older workers further compound their economic challenges.

Zaniboni (2015) argues that when older workers cannot adapt to new job requirements, particularly those requiring technological proficiency, they experience social exclusion, leading to isolation and lower mental health outcomes. Many older workers in Thailand lack access to retraining opportunities, placing them at a disadvantage compared to younger workers with better access to education and skills development (World Bank, 2025). This exclusion hinders their ability to transition into new roles or industries, which in turn negatively impacts their quality of life and ability to remain economically active. To address these issues, policymakers in Thailand must take proactive measures to combat age discrimination and support older workers in remaining integrated into the labor market. Blau (2025) emphasizes the importance of policies that extend the working lives of older individuals while combating workplace discrimination. Countries like Japan and Singapore, which have implemented flexible working arrangements and comprehensive retraining programs, serve as effective models for Thailand (Zaniboni, 2015). Moroz & Naddeo (2025) recommend expanding social protection programs to ensure older workers' financial security, thus reducing the pressure to remain in the workforce out of necessity. Additionally, investment in skills training, career counseling, and flexible work arrangements is essential to fostering a more inclusive labor market for older workers.

In conclusion, Thailand's aging population poses significant challenges for older workers in the labor market. As the working-age population declines and older workers face exclusion from higher-paying and stable job opportunities, addressing age discrimination becomes critical. Without comprehensive policies that support older workers, particularly those in rural and informal sectors, Thailand's labor market risks leaving a substantial portion of its population economically vulnerable and socially marginalized. Targeted policy reforms will be crucial to ensuring that older workers can continue to contribute meaningfully to the economy.

1. Prevalence of Age Discrimination in Thailand

Age discrimination, or ageism, is a significant challenge that affects older workers in many labor markets, including Thailand. This issue limits older individuals' access to employment opportunities, career advancement, and economic mobility. Despite legal frameworks such as the Labor Protection Act of 1998, which prohibits age-based discrimination, the effectiveness of these laws remains weak, and older workers

continue to face significant barriers in securing stable, high-quality jobs. Research by the World Bank (2025) reveals that the labor force participation rate for older workers in Thailand, particularly those aged 65 and above, is notably lower compared to other countries in the East Asia and Pacific region. The International Labour Organization (ILO) (2025) identifies that older workers in Thailand face both overt and subtle forms of age discrimination in hiring, retention, and promotions, with employers often perceiving them as less adaptable or technologically proficient than younger workers. Comparing Thailand with its regional neighbors, such as Cambodia and Indonesia, further focuses on the prevalence of age discrimination. These countries have higher labor force participation rates for older workers and have implemented active policies to promote their employment (ILO, 2025). In contrast, Thailand lags behind, with older workers often pushed into informal labor markets where they face lower wages and less job security. Zaniboni (2015) suggests that while older workers possess valuable experience, they are often overlooked in favor of younger workers, especially in the private sector, where productivity and adaptability are prized over experience. Age discrimination in Thailand is not limited to overt forms but also includes subtle and covert practices. Moroz and Naddeo (2025) emphasize that older workers are frequently bypassed during recruitment processes or given fewer opportunities for training and career development. Blau (2025) notes that, while job listings may not explicitly state an age requirement, older applicants are rarely considered for interviews or promotions, a form of discrimination that can be harder to identify but is nonetheless damaging to their employment prospects. This issue is particularly pronounced in industries undergoing rapid technological advancements, where older workers are excluded from digital job markets due to a lack of opportunities to upskill, despite having the requisite experience (Zaniboni, 2015). Cultural and institutional factors in Thailand further contribute to the prevalence of age discrimination. Moroz & Naddeo (2025) argue that there is a strong cultural preference for youth, especially in urban settings, where younger workers are seen as more suitable for high-energy, innovative, and adaptable roles. This cultural bias, combined with institutional factors such as weak enforcement of anti-discrimination laws and inadequate support systems for older workers, perpetuates the exclusion of older workers from the formal labor market. The lack of retraining programs and pension

schemes forces many older workers to remain in the workforce well past retirement age, often in low-paying, insecure jobs (Zaniboni, 2015). The economic and social impact of age discrimination is profound. As noted by the World Bank (2025), older workers are often relegated to informal or lower-wage sectors, creating a cycle of economic dependence. This marginalization not only impacts their financial well-being but also their mental and physical health, as exclusion from the workforce can lead to a loss of identity and purpose. Social isolation further exacerbates the challenges faced by older workers, particularly for those without strong social support networks (Blau, 2025).

In conclusion, age discrimination in Thailand's labor market remains a significant barrier to the full participation of older workers. Despite legal protections, both direct and indirect forms of discrimination persist, limiting older workers' access to stable and well-paying employment. Cultural biases, combined with institutional shortcomings, exacerbate the issue, particularly as Thailand faces demographic shifts due to an aging population. With understand the extent and forms of age discrimination is critical for developing effective policies that can mitigate its impact and create a more inclusive labor market for older workers.

2. Barriers Faced by Older Workers

Older workers in Thailand face multiple barriers that hinder their participation in the labor market, which are not limited to economic factors but also extend to social, psychological, and systemic issues. One of the primary barriers is the rapid pace of technological change. Zaniboni (2015) notes that many older workers, particularly those over 50, have limited access to new skill development opportunities, especially in sectors increasingly reliant on digital technologies. The World Bank (2025) highlights the lack of digital literacy among older workers, particularly in rural areas or manual labor sectors, which exacerbates their inability to meet the evolving demands of the labor market. Without access to retraining programs, older workers are often displaced and struggle to find stable, higher-paying jobs in the modern economy (Moroz & Naddeo, 2025). Another significant barrier is employer biases and age-related stereotypes. Blau (2025) argues that older workers are often viewed as less adaptable, less productive, and more expensive than their younger counterparts, which leads to them being overlooked for promotions, training opportunities, and even during the hiring process. The ILO (2025)

reports that despite legal protections against age discrimination in Thailand, these biases persist in the hiring and promotion processes, with older workers often excluded from roles that require creativity or fast-paced problem-solving. This issue is compounded for older women, who experience a "double disadvantage" due to both age and gender biases, limiting their opportunities and contributing to income inequality (Zaniboni, 2015). Health-related issues also pose a significant challenge for older workers. As Blau (2025) explains, older workers are more likely to suffer from chronic conditions such as arthritis or cardiovascular diseases, which can affect their ability to perform physical tasks or work long hours. The World Bank (2025) notes that these health challenges often result in higher absenteeism and lower productivity, reinforcing stereotypes that older workers are less valuable. In some cases, the lack of flexibility in retirement policies and inadequate healthcare systems forces older workers into early retirement, even when they are physically capable of continuing to work (Moroz & Naddeo, 2025). This premature exit from the workforce undermines their economic security and well-being. Social and psychological barriers also significantly impact older workers. Zaniboni (2015) discusses how exclusion from the workforce or relegation to lower-wage jobs can lead to social isolation, loss of self-esteem, and a diminished sense of purpose. The World Bank (2025) highlights that older workers, especially in rural areas, may face additional challenges due to limited access to professional networks, further isolating them from job opportunities. Psychological barriers, such as self-doubt and fear of dismissal due to age, often prevent older workers from seeking new employment, leading them to accept lower-paying, less fulfilling jobs or withdraw from the labor market altogether (ILO, 2025).

Additionally, inadequate retirement planning and savings present another major barrier for older workers. Zaniboni (2015) points out that while Thailand's social security system provides some support, many older workers still lack sufficient financial resources to retire comfortably, forcing them to remain in the workforce longer, often in insecure and lower-paying jobs. The World Bank (2025) further emphasizes that older workers in informal employment, who lack access to pension schemes, are particularly vulnerable to financial insecurity, perpetuating a cycle of economic inequality. In conclusion, older workers in Thailand face a combination of technological, employer, health, social, psychological, and financial barriers that limit their participation in the

labor market. These barriers prevent them from accessing high-quality, stable employment and contribute to broader economic inequality and social exclusion. Addressing these challenges requires comprehensive policy reforms that focus on training, anti-discrimination laws, healthcare, and social protection to ensure that older workers can remain integrated into the labor market and continue to contribute productively to the economy.

3. Changes in the Labor Market

The labor market in Thailand has undergone significant changes over the past few decades, driven by technological advancements, globalization, demographic shifts, and the transition to knowledge-based industries. These changes have created both opportunities and challenges, particularly for older workers who are often vulnerable to job displacement and exclusion. Technological advancements and the increasing reliance on digital tools and automation have been pivotal in transforming the labor market. Zaniboni (2015) notes that older workers, particularly those in traditional industries such as agriculture and manufacturing, face considerable challenges in adapting to new technologies. As industries evolve toward digital platforms, artificial intelligence, and robotics, older workers without digital skills are increasingly marginalized, with younger, more tech-savvy employees benefiting from job creation in emerging industries (World Bank, 2025). Moroz & Naddeo (2025) emphasize that the growing demand for high-tech skills further pushes older workers out of the labor market, as they struggle to keep pace with the demands of technology-driven sectors.

Globalization has also played a significant role in reshaping Thailand's labor market, increasing trade, foreign investment, and competition, thereby driving the demand for a more flexible and mobile workforce. Zaniboni (2015) explains that older workers, who may have spent decades in stable, traditional jobs, often lack the adaptability required to meet the demands of a globalized labor market. The rise of temporary contracts, gig economy jobs, and freelance work has introduced further job insecurity, with older workers in informal sectors facing lower wages and limited benefits (Moroz & Naddeo, 2025). This shift has exacerbated their vulnerability, especially as they are excluded from social protection systems such as pensions and health insurance, leaving them with limited economic security. The aging population in Thailand presents both opportunities and challenges. As fertility rates decline and life expectancy increases, the

proportion of older workers in the labor force is rising, placing additional pressure on the workforce. According to the World Bank (2025), the number of people aged 65 and older is projected to grow significantly, increasing the demand for services such as healthcare, elder care, and retirement planning. However, Zaniboni (2015) highlights that this demographic shift also contributes to a shrinking labor force, as fewer working-age individuals are available to replace retiring workers. Older workers, while required to stay in the workforce longer, often face difficulties due to age-related health issues, limited skill development opportunities, and the biases associated with age discrimination. This scenario creates an economic dilemma, where older workers are forced to remain employed past traditional retirement age but struggle to find fulfilling and sustainable employment.

The transition from labor-intensive industries to knowledge-based sectors is another key change affecting older workers. Zaniboni (2015) points out that many older workers, particularly those from rural areas with backgrounds in manual labor, are ill-prepared to transition to the service and knowledge industries that require higher education and specialized skills. The World Bank (2025) further emphasizes that older workers lacking educational qualifications or technical expertise are often excluded from emerging job opportunities in sectors such as information technology, finance, and health services. This exclusion limits their income potential and career advancement, contributing to their economic vulnerability. The COVID-19 pandemic has further accelerated these labor market changes, prompting widespread digitalization and the adoption of remote work practices. Older workers were disproportionately affected by these shifts, as many lacked the technological proficiency or the ability to work from home. Moroz & Naddeo (2025) explain that older workers, particularly in industries forced to shut down or transition to remote work, were often the first to be laid off or pushed out of the workforce. The pandemic also exposed the fragility of social support systems for older workers, with many left without sufficient safety nets or retraining opportunities, exacerbating the barriers they already faced (Blau, 2025). This disruption underscored the urgent need for more robust social protection policies and greater flexibility in the labor market to accommodate older workers, particularly during crises.

In conclusion, the labor market in Thailand is undergoing significant transformations driven by technological advancements, globalization, demographic shifts, and the rise of knowledge-based industries. While these changes have created new opportunities, they have also presented substantial challenges for older workers, who face barriers such as limited access to retraining, employer biases, and a lack of job security. To ensure that older workers remain engaged in the labor market and continue contributing to the economy, it is crucial to invest in lifelong learning, workplace accommodations, and social protection systems. Addressing these specific barriers through targeted policy interventions is essential for creating a more inclusive labor market for older workers.

4. Challenges and Future Outlook

Thailand's aging population presents significant challenges to its labor market, particularly for older workers who face a multitude of barriers to remaining active and engaged in the workforce. One of the primary challenges is the rapid pace of technological change. Many older workers, especially those in rural areas or manual labor sectors, struggle to keep up with advancements in digital tools and automation, often leaving them marginalized in industries that require digital literacy. This technological divide, combined with age discrimination, further limits their access to stable, high-paying jobs. Despite legal frameworks like the Labor Protection Act of 1998, older workers continue to face biases in hiring and promotions, with employers perceiving them as less adaptable and technologically proficient. Additionally, health-related challenges, such as chronic conditions that affect productivity, and the lack of comprehensive social protection, such as pension schemes and retirement savings, exacerbate the financial insecurity of older workers. Many are forced into informal, low-wage jobs where job stability is minimal, creating a cycle of economic dependence. Moreover, the exclusion of older workers from retraining and career support programs leaves them ill-prepared to transition into knowledge-based industries that are rapidly growing in Thailand. Looking ahead, the future of older workers in Thailand hinges on the implementation of comprehensive policy reforms. These reforms must address age discrimination, expand social protection systems, and invest in lifelong learning and retraining opportunities. Countries like Japan and Singapore have successfully integrated older workers into the

labor market by offering flexible work arrangements and retraining programs, and Thailand could benefit from similar policies. By ensuring that older workers have access to the resources they need to adapt to technological changes, Thailand can create an inclusive labor market where older workers continue to contribute meaningfully to the economy. Ultimately, the challenge lies in balancing the demands of an aging population with the need to maintain a dynamic and productive workforce, and this can be achieved through targeted policies that support the inclusion of older workers in modern industries.

Conclusion

Thailand is facing a pressing challenge as its population ages, which is having a significant impact on the labor market. Older workers are dealing with a range of difficulties, from age discrimination and technological barriers to health issues and limited access to retraining opportunities. As a result, many older workers find themselves pushed into informal, low-paying jobs, which increases economic inequality and marginalizes them from the benefits of a rapidly evolving economy. Even though there are laws meant to protect against age discrimination, these often fall short in practice, leaving older workers vulnerable to bias and exclusion.To address these issues, Thailand needs to adopt a set of policies that support older workers and ensure they can continue to contribute to the economy. First, strengthening the enforcement of anti-age discrimination laws is crucial, alongside providing incentives for employers to hire and retain older workers. Expanding social protection programs, including better pensions and healthcare, will also help ensure financial security for older workers, reducing the need for them to remain in low-wage jobs. Investing in digital skills training and retraining opportunities is another key step, especially for older workers who may not have access to these resources, particularly in rural areas.

Additionally, making the labor market more inclusive for older workers means offering flexible working arrangements, such as job-sharing or remote work, which can help them stay in the workforce longer without compromising their health or well-being. Thailand can look to countries like Japan and Singapore, which have successfully integrated older workers into their labor markets by offering retraining programs and flexible work policies. If Thailand follows suit, it can create an environment where older

workers are valued for their experience and can continue to thrive in the modern economy.

Eventually, the future of Thailand's labor market depends on its ability to embrace an aging population. By implementing thoughtful, inclusive policies, the country can ensure that older workers remain active contributors to the economy, helping to build a sustainable and resilient workforce for the future.

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Development of a Mathematics Learning Management Model Emphasizing Authentic Assessment to Promote Executive Functions of Lower Secondary School Students

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Abstract

This research aimed to 1) study the state of mathematics learning management emphasizing authentic assessment and the state of executive functions, and 2) develop a model and verify the quality of mathematics learning management emphasizing authentic assessment to promote executive functions of lower secondary school students in Chiang Rai province. The sample consisted of 411 lower secondary mathematics teachers in Chiang Rai province. The data were analyzed using descriptive statistics, Exploratory Factor Analysis (EFA), and Second-Order Confirmatory Factor Analysis (CFA). The research findings revealed that: (1) The state of mathematics learning management consisted of 9 factors, explaining 87.92% of the total variance. Meanwhile, the state of executive functions consisted of 7 factors, explaining 87.38% of the total variance. All indicators exhibited high factor loadings, indicating clear construct structures. (2) The verification of the structural model quality demonstrated that the learning management model fitted the empirical data perfectly χ^2 /df = 2.35, RMSEA = 0.057, CFI = 0.936, TLI = 0.931, SRMR = 0.070). Similarly, the executive function model indicated a good fit with the empirical data χ^2 /df = 2.65, RMSEA = 0.053, CFI = 0.942, TLI = 0.932, SRMR = 0.070). These findings confirmed the construct validity of the developed models and measurement tools, verifying their quality and suitability to be utilized as guidelines for instructional design to effectively enhance students' executive functions.

Keywords: Executive Functions, Authentic Assessment, Mathematics Learning Management

Background and Statement of the problem

Education in the twenty-first century emphasizes the development of learners' higher-order competencies, including analytical thinking, problem-solving, adaptability, and self-regulation, to enable effective functioning in rapidly changing societal contexts. This orientation aligns with Thailand's National Education Plan (2017–2036), which prioritizes the holistic development of learners' potential. A key underlying mechanism of these competencies is Executive Functions (EF), a set of higher-order cognitive processes that regulate behavior, cognition, and emotion in alignment with goal-directed actions. Core components of EF include working memory, inhibitory control, cognitive flexibility, planning, and self-monitoring.

A substantial body of research has demonstrated a significant relationship between EF and mathematics achievement. Bull and Lee (2014) indicated that EF—particularly working memory, inhibition, and shifting—plays a critical role in mathematics learning, including computation, reasoning, and problem-solving. Similarly, Cragg et al. (2017) found that EF influences mathematics achievement both directly and indirectly, suggesting that success in mathematics is not solely dependent on content knowledge but also on learners' ability to organize information, regulate attention, and adapt their thinking strategies to situational demands. Furthermore, Živković et al. (2022), in a study of lower secondary students, reported that visuospatial working memory and cognitive flexibility were positively associated with mathematics achievement, whereas mathematics anxiety was negatively associated and may exert its effects through EF mechanisms. These findings underscore the critical role of EF during early adolescence, a developmental stage characterized by increasing mathematical complexity.

Despite this evidence, mathematics instruction continues to face significant limitations in assessment practices. Most assessments primarily focus on the correctness of answers through selected-response or constructed-response formats, rather than evaluating cognitive processes, reasoning, and the application of knowledge in authentic contexts. Nortvedt and Buchholtz (2018) argued that contemporary mathematics assessment must evolve toward approaches capable of capturing learners' complex competencies, including thinking, communication, and meaningful application of knowledge. In this regard, authentic assessment has gained increasing attention, as it

provides opportunities for learners to demonstrate their capabilities through real-world tasks, incorporates continuous feedback, and promotes active engagement in the learning process.

Within the context of mathematics learning, McFeetors and Palfy (2021) suggested that the authenticity of assessment should not be confined to end-of-unit evaluations but should be continuously integrated into the learning process to support meaning-making and learner engagement. However, Syaifuddin (2020) found that lower secondary mathematics teachers, while attempting to implement authentic assessment, encounter challenges related to time constraints, workload, and scoring reliability. This indicates that the practical implementation of authentic assessment remains insufficiently structured and lacks systematic models.

From a theoretical perspective, authentic assessment holds substantial potential for fostering executive functions (EF), as its learning activities require sustained engagement in higher-order cognitive processes, including planning, problem-solving, strategy adjustment, and reflective thinking. These processes are directly aligned with core EF components such as working memory, inhibitory control, cognitive flexibility, and self-monitoring. Importantly, key instruments within authentic assessment—such as rubrics and self-assessment—function as explicit mechanisms for activating EF. The use of rubrics requires learners to simultaneously maintain and process multidimensional criteria within working memory while continuously comparing their performance against these standards, thereby enhancing information organization and attentional regulation. Concurrently, interpreting criteria and revising work based on feedback necessitate cognitive flexibility, as learners must shift perspectives and adapt their strategies in response to evolving task demands. Moreover, self-assessment promotes EF through metacognitive and self-regulatory processes, as learners engage in monitoring their thinking, evaluating the quality of their work, and planning subsequent improvements. This cyclical process of self-regulation is intrinsically linked to EF development. Therefore, authentic assessment should be conceptualized not merely as a tool for measuring learning outcomes but as a process-oriented mechanism that systematically cultivates executive functions within the context of mathematics learning.

A review of both national and international literature indicates that the current body of knowledge remains fragmented. Although research consistently confirms the relationship between EF and mathematics achievement, and highlights the potential of authentic assessment to promote meaningful learning, there is a lack of studies that systematically integrate these two constructs within mathematics instructional design, particularly at the lower secondary level.

Accordingly, a critical gap in the literature lies in the absence of a mathematics instructional model that explicitly integrates authentic assessment to promote learners' EF, supported by empirical evidence—especially within the Thai educational context. Furthermore, there is limited understanding of how specific components of authentic assessment—such as real-world tasks, the use of rubrics, self- and peer-assessment, and continuous feedback—contribute to the development of particular EF dimensions in mathematics learning.

In response to these gaps, the present study on the development of a mathematics instructional model based on authentic assessment to enhance executive functions among lower secondary students is of substantial significance, both theoretically and practically. Theoretically, the study contributes to a systematic integration of EF frameworks with mathematics assessment paradigms. Practically, it provides teachers with a structured approach to designing learning experiences and assessment practices that align with learners' cognitive processes and self-regulatory capacities, thereby fostering the development of essential competencies required for the twenty-first century.

Objective

1. To investigate the current conditions of mathematics instructional management emphasizing Authentic Assessment, as well as the Executive Functions of lower secondary school students.

2. To develop and examine the quality of a mathematics instructional model grounded in Authentic Assessment to enhance the Executive Functions of lower secondary school students.

Expected benefits

1. To identify the components and indicators of mathematics instructional management grounded in Authentic Assessment aimed at enhancing the Executive Functions of lower secondary students.

2. To obtain a concrete instructional model that can serve as a practical guideline for teachers and educational personnel in designing and implementing learning processes that promote students' Executive Functions.

3. To promote and develop the Executive Functions of lower secondary students, which constitute essential foundational skills for both academic learning and everyday life.

Conceptual Framework

1. The researcher synthesized relevant concepts and theories to establish the foundational basis for defining the variables and structural framework of the study, as follows:

Authentic Learning and Assessment Theory

This study draws upon the conceptual framework of Wiggins (1998) and the Ministry of Education, which emphasize organizing mathematics learning experiences that are meaningfully connected to real-life contexts. Within this framework, learners actively construct knowledge through engagement in authentic tasks. Assessment is integrated into the instructional process through formative assessment practices, with particular emphasis on continuous feedback to enable students to refine their learning strategies. Based on this theoretical foundation, the researcher synthesized a mathematics instructional model comprising nine core components.

Executive Functions (EF) Theory

The study is grounded in the cognitive neuroscience framework proposed by Diamond (2013) and further elaborated by the RLG Institute. This perspective explains the role of the frontal lobe in regulating cognition, emotion, and behavior toward goal-directed actions. Executive Functions encompass both core foundational skills and higher-order skills. The researcher integrated this theoretical framework with the context

of mathematics learning and synthesized a structure of Executive Functions for lower secondary students consisting of seven components.

2. Conceptual Framework of the Study

Based on the literature review, the researcher developed a conceptual framework aimed at examining the structural relationship between a mathematics instructional model emphasizing Authentic Assessment (independent variable/process) and the development of students' Executive Functions (dependent variable/outcomes)

3. Research Hypotheses

3.1 The structural relationship model of the mathematics instructional approach emphasizing Authentic Assessment is consistent with the empirical data.

3.2 The structural relationship model of the Executive Functions of lower secondary students is consistent with the empirical data.

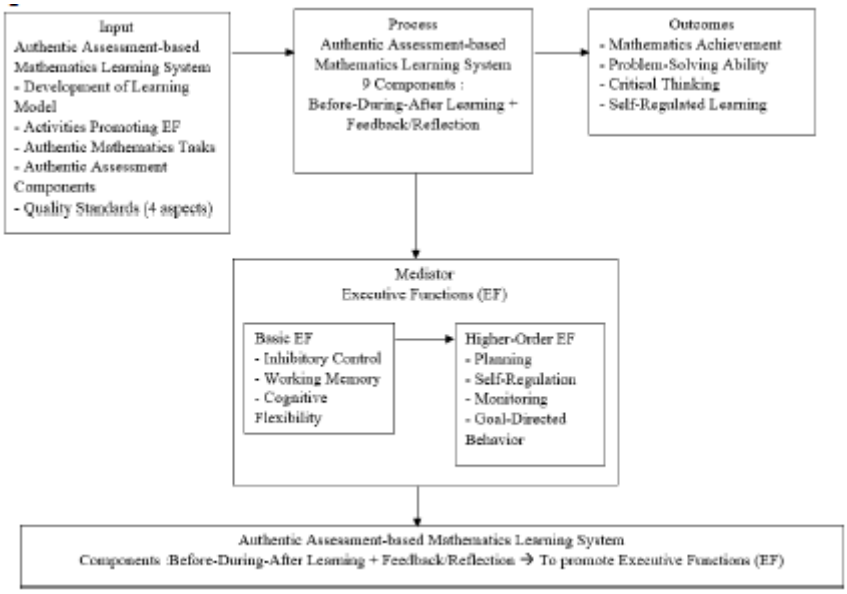


Figure 1 The proposed conceptual framework integrating authentic assessment-based mathematics learning and executive functions (EF)

Research Methodology

Population

The population comprised mathematics teachers teaching in educational institutions in Chiang Rai Province during the 2024 academic year (B.E. 2567). These included schools under the Office of the Basic Education Commission, categorized into

Secondary Educational Service Area Offices, Primary Educational Service Area Offices (Areas 1–4), local administrative organizations, and private institutions.

Try-Out Sample

In this study, data were collected from two independent samples to support distinct analytical procedures, as follows.

The sample for Exploratory Factor Analysis (EFA) consisted of 100 participants and was used for preliminary instrument validation (try-out phase). This sample size meets the minimum acceptable criteria for factor analysis (Gorsuch, 1983; Kline, 1994) and is consistent with Cattell's (1978) recommendation of a minimum sample-to-variable ratio of 3:1. Participants were selected using purposive sampling from schools with contextual characteristics similar to those of the target population, but not included in the actual study sample. The inclusion criteria were as follows: (1) participants were lower secondary mathematics teachers during the academic years 2022–2024, and (2) participants voluntarily agreed to participate in the study. This sample was employed to pilot the questionnaire, assess its reliability, and conduct EFA in order to refine and improve the instrument prior to its administration to the main sample.

The sample for Confirmatory Factor Analysis (CFA) comprised 411 lower secondary mathematics teachers in Chiang Rai Province and was used for the main data collection. Participants were selected using stratified sampling based on school size, including extra-large, large, medium, and small schools. Subsequently, proportionate stratified sampling was applied to ensure appropriate representation across strata. A total of 450 questionnaires were distributed, and 411 were returned, yielding a response rate of 91.33%. The CFA sample was independent from the pilot sample to minimize bias associated with using the same dataset for both instrument development and structural validation (Hair et al., 2019; Kline, 2016; Tabachnick & Fidell, 2013).

Research Instruments

The research instrument consisted of one questionnaire divided into three parts:

Part 1: General Information

A checklist format was used to collect demographic information from respondents.

Part 2: Instructional Management Emphasizing Authentic Assessment

This section comprised 34 five-point Likert-scale items measuring indicators of mathematics instructional management emphasizing Authentic Assessment to promote Executive Functions in lower secondary students.

The initial conceptual framework consisted of nine components: (1) Learning objective formulation promoting Executive Function (2) Principles of learning activity implementation (3) Learning activity management (4) Instructional media promoting Executive Function (5) Classroom environment promoting Executive Function (6) Authentic measurement and evaluation (7) Utilization of assessment results for learning improvement (8) Post-instructional documentation (9) Goal setting and strategic adjustment

Rating scale interpretation: 5 = Always practiced, 4 = Very frequently practiced, 3 = Frequently practiced, 2 = Occasionally practiced,1 = Rarely practiced. The empirical factor structure was subsequently verified using Exploratory Factor Analysis (EFA).

Part 3: Executive Function Behavioral Indicators

This section included 26 five-point Likert-scale items measuring students' Executive Function behaviors across seven components: (1) Inhibitory control (2) Working memory (3) Planning and self-management (4) Cognitive flexibility (5) Attention and focus (6) Self-regulation and self-monitoring (7) Goal-directed persistence

Rating scale interpretation: 5 = Always demonstrates behavior, 4 = Very frequently demonstrates behavior, 3 = Frequently demonstrates behavior, 2 = Occasionally demonstrates behavior, 1 = Rarely demonstrates behavior

Instrument Development and Quality Assurance

The instrument development process included:

1. Reviewing relevant literature on Authentic Assessment, EF-promoting instructional management, and EF behavioral indicators for lower secondary students.
2. Establishing a conceptual framework for questionnaire construction.
3. Developing items based on prior studies (Saengsawang, 2016; Jankhajorn, 2017; Santanarattavechmongkol, 2019).
4. Submitting the instrument to the thesis advisor for content accuracy and linguistic appropriateness.
5. Requesting formal appointment of expert reviewers from the Faculty of Education, Chiang Mai University.

6. Having five experts evaluate content validity using the Index of Item Objective Congruence (IOC). Items with IOC values between 0.60–1.00 were retained; items below 0.60 were revised or removed.

7. Conducting a try-out with 100 teachers and analyzing reliability using Cronbach's alpha. The reliability coefficient was 0.89.KMO = 0.723, Bartlett's Test = 3436.777, df = 561, $p < .001$ (statistically significant)

8. Performing EFA, which yielded nine empirical components: (1) Learning objective formulation promoting Executive Function (2) Principles of learning activity implementation (3) Learning activity management (4) Instructional media promoting Executive Function (5) Classroom environment promoting Executive Function (6) Authentic measurement and evaluation (7) Utilization of assessment results for learning improvement (8) Post-instructional documentation (9) Goal setting and strategic adjustment.

The structure was theoretically consistent and appropriate for subsequent Confirmatory Factor Analysis (CFA).

Data Collection

Data collection proceeded in two sequential phases—a pilot study and the main administration to perfectly align with the research design and analytical procedures.

Phase 1: Pilot Study (Instrument Refinement): To evaluate the quality of the research instrument, data were initially collected from a pilot sample of 100 lower secondary mathematics teachers. Participants were selected via purposive sampling from schools sharing contextual characteristics with the target population. This preliminary dataset was utilized to assess instrument reliability and conduct an Exploratory Factor Analysis (EFA) for initial construct validation and item refinement.

Phase 2: Main Study (Model Validation): The primary data collection involved 411 lower secondary mathematics teachers in Chiang Rai Province. Following official approval from the Faculty of Education, Chiang Mai University, and coordination with the relevant Educational Service Area Offices, questionnaires were distributed using proportionate stratified random sampling based on school size. Of the 450 distributed questionnaires, 411 valid responses were returned, yielding a robust response rate of

91.33%. All submissions were rigorously screened for completeness and accuracy prior to analysis. This final dataset was exclusively employed to conduct the Confirmatory Factor Analysis (CFA).

Importantly, maintaining strictly independent samples for the EFA and CFA phases prevented method bias, thereby maximizing the validity and methodological rigor of the instrument development process.

Data Analysis

Data Analysis Procedures

Part 1: Descriptive statistics (frequency, percentage, mean).

Part 2: Analysis of instructional management components using mean and standard deviation, interpreted according to the following scale:

4.51–5.00 = Highest level, 3.51–4.50 = High, 2.51–3.50 = Moderate, 1.51–2.50 = Low, 1.00–1.50 = Lowest

Part 3: Analysis of EF behavioral indicators using the same statistical procedures and interpretation criteria.

Part 4: Second-order Confirmatory Factor Analysis (CFA) to examine construct validity and model fit.

Statistical Techniques

Descriptive Statistics, Mean, Standard deviation, Instrument Quality Testing, Content validity (IOC), Reliability (Cronbach's alpha), Hypothesis Testing and CFA Procedures, Pearson correlation matrix, Bartlett's Test of Sphericity, Kaiser-Meyer-Olkin (KMO) Measure, First-order CFA, Second-order CFA

Model Fit Indices

Chi-square (χ^2), Goodness-of-Fit Index (GFI > 0.90), Adjusted Goodness-of-Fit Index (AGFI > 0.90)

Comparative Fit Index (CFI > 0.95), Relative Chi-square ($\chi^2/df \leq 3$), Standardized Root Mean Square Residual (SRMR < 0.08), Root Mean Square Error of Approximation (RMSEA < 0.06). These indices were used to determine the congruence between the theoretical model and the empirical data.

Research Results

The findings are presented in two major sections: (1) results of the Exploratory Factor Analysis (EFA), and (2) results of the Second-Order Confirmatory Factor Analysis (CFA), conducted to develop and validate the structural components of mathematics instructional management emphasizing Authentic Assessment to promote Executive Functions (EF), and the structural components of Executive Functions among lower secondary students.

Part I: Exploratory Factor Analysis (EFA)

1. Instructional Management Emphasizing Authentic Assessment.

Prior to factor extraction, data suitability was evaluated. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was .723, exceeding the acceptable threshold of .70. Additionally, Bartlett's Test of Sphericity was highly significant (χ^2 = 3436.777, df = 561, $p < .001$), confirming that the correlation matrix was not an identity matrix. Together, these results demonstrate sufficient intercorrelation among the variables, indicating that the dataset met the necessary assumptions and was highly appropriate for Exploratory Factor Analysis (EFA).

Table 1 show Factor extraction results and explained variance

The nine components identified	Eigenvalue	% of Variance	Cumulative %
Learning objective formulation promoting EF	5.467	16.081	16.081
Principles of learning activity implementation	4.817	14.169	30.249
Learning activity management	3.791	11.149	41.398
Instructional media promoting EF	3.721	10.944	52.342
Classroom environment promoting EF	3.136	9.225	61.567
Authentic measurement and evaluation	2.557	7.520	69.087
Utilization of assessment results for learning improvement	2.485	7.308	76.395
Post-instructional documentation	2.387	7.020	83.415
Goal setting and strategic adjustment	1.532	4.507	87.922

Based on Kaiser's criterion (eigenvalues > 1), the Exploratory Factor Analysis (EFA) extracted a nine-factor solution. The initial three factors yielded the highest eigenvalues of 5.467, 4.817, and 3.791, respectively. The first factor alone accounted for 16.081% of the variance, while all nine factors collectively explained a substantial 87.922% of the total variance. This high level of cumulative variance indicates that the

extracted factors efficiently and comprehensively represent the underlying data structure. Overall, the results confirm that the observed variables clustered into nine distinct, interpretable factors, providing a robust empirical foundation for the subsequent Confirmatory Factor Analysis (CFA).

Table 2 show Factor summary

Component	Factor Loading
Component 1: Formulation of Learning Objectives Promoting Executive Functions *Observed Variables*	
- Formulating learning objectives that encourage students to connect prior knowledge with new knowledge	.931
- Formulating learning objectives that promote the extension of knowledge to new situations	.942
Component 2: Principles of Learning Activity Implementation Promoting Executive Functions *Observed Variables*	
- Implementing learning activities that ensure continuous student participation	.924
- Implementing learning activities that promote reflective thinking before action	.922
- Implementing learning activities that stimulate students to explain their reasoning	.909
- Implementing learning activities that foster responsibility for assigned tasks	.898
Component 3: Learning Activity Management Promoting Executive Functions *Observed Variables*	
- Organizing learning activities that allow students to plan their work independently	.907
- Organizing learning activities that engage students in step-by-step hands-on practice	.895
- Organizing learning activities that encourage students to solve problems using multiple approaches	.928
- Organizing learning activities that provide opportunities for students to exchange ideas	.917
Component 4: Instructional Media Promoting Executive Functions *Observed Variables*	
- Utilizing instructional media appropriate to students' ability levels	.921
- Utilizing instructional media that enhance students' interest and sustained attention	.909
- Utilizing instructional media that encourage students to think, analyze, and make decisions	.867
- Utilizing diverse instructional media that support active learning	.919
Component 5: Classroom Environment Promoting Executive Functions *Observed Variables*	
- Organizing a classroom environment that supports collaborative learning	.924
- Establishing a classroom climate that allows students to express their opinions safely	.910
- Arranging seating or learning spaces that facilitate group work	.912
- Fostering positive teacher–student relationships	.909
Component 6: Measurement and Evaluation Emphasizing Authentic Assessment *Observed Variables*	
- Conducting assessment aligned with authentic assessment principles	.929
- Using observation of students' behaviors as part of the evaluation process	.930
- Assessing students in ways that reflect their thinking processes and work performance	.919
- Providing opportunities for students to participate in self-assessment	.900
Component 7: Utilization of Assessment Results for Reflective Learning Improvement *Observed Variables*	
- Using assessment results to continuously improve students' learning	.937
- Recording post-instructional reflections to refine teaching practices	.930
- Engaging in reflective discussion of learning outcomes with students	.951
- Applying reflective feedback to adjust subsequent learning activities	.904

Component	Factor Loading
Component 8: Post-Instructional Documentation *Observed Variables*	
- Managing instructional materials and resources to ensure adequacy and appropriateness for activities	.939
- Encouraging students to take responsibility for shared instructional materials	.911
- Designing activities that facilitate students' self-assessment	.889
- Encouraging students to monitor their own learning progress	.919
Component 9: Goal Setting and Strategic Adjustment *Observed Variables*	
- Organizing activities that help students set learning goals	.923
- Providing opportunities for students to adjust their own learning strategies	.933
- Offering feedback that supports students' self-regulation development	.935
- Designing learning experiences that encourage students to learn from mistakes	.940

The Exploratory Factor Analysis (EFA) yielded a well-defined nine-factor structure. All observed variables demonstrated strong factor loadings exceeding .80, indicating robust construct validity and confirming that each item contributed significantly to its underlying factor. Specifically, the extracted factors, their loading ranges, and conceptual representations are as follows:

-Formulation of Learning Objectives Promoting Executive Functions (.931–.942): Focuses on knowledge integration and extension.

-Principles of Learning Activity Implementation Promoting Executive Functions (.898–.924): Emphasizes student engagement, reflective thinking, and learner responsibility.

-Learning Activity Management Promoting Executive Functions (.895–.928): Provides opportunities for planning, active engagement, and diverse problem-solving.

-Instructional Media Promoting Executive Functions (.867–.921): Stimulates thinking, analysis, and decision-making.

-Classroom Environment Promoting Executive Functions (.909–.924): Facilitates collaborative learning through a supportive atmosphere and contextual conditions.

-Measurement and Evaluation Emphasizing Authentic Assessment (.900–.930): Reflects cognitive processes and promotes active learner participation.

-Utilization of Assessment Results for Reflective Learning Improvement (.904–.951): Highlights the role of feedback in enhancing the learning process.

-Post-Instructional Documentation (.889–.939): Underscores the importance of continuous monitoring and evaluation of student development.

-Goal Setting and Strategic Adjustment (.923–.940): Targets the development of learners' self-regulation and strategic planning abilities.

Overall, the EFA results confirm that this nine-factor structure effectively represents the multidimensional construct of mathematics instructional management based on authentic assessment to promote executive functions. The derived structure is consistent with the theoretical framework and provides a robust empirical foundation for subsequent validation through Confirmatory Factor Analysis (CFA).

2. Executive Functions

Prior to conducting the Exploratory Factor Analysis (EFA), data suitability was evaluated. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was .742, exceeding the acceptable threshold of .70. Additionally, Bartlett's Test of Sphericity was highly significant ($\chi^2 = 2537.045$, df = 325, $p < .001$), confirming that the correlation matrix was not an identity matrix. Together, these results indicate sufficient intercorrelation among the variables, demonstrating that the dataset met the necessary assumptions for factor extraction.

Table 3 show Factor extraction results and explained variance

The seven components identified	Eigenvalue	% of Variance	Cumulative %
Inhibitory control	5.167	19.873	19.873
Working memory	3.966	15.253	35.126
Planning and self-management	3.524	13.553	48.680
Cognitive flexibility	2.984	11.476	60.156
Attention and focus	2.812	10.816	70.972
Self-regulation and self-monitoring	2.153	8.281	79.253
Goal-directed persistence	2.112	8.122	87.375

Based on Kaiser's criterion (eigenvalues > 1), the Exploratory Factor Analysis (EFA) extracted a seven-factor model of executive functions (EF). The initial three factors—Inhibitory Control, Working Memory, and Planning and Self-Management—yielded the highest eigenvalues of 5.167, 3.966, and 3.524, respectively. The first factor alone explained 19.873% of the variance, while all seven factors collectively accounted for a substantial 87.375% of the total variance, demonstrating a highly efficient and comprehensive representation of the observed variables.

The extracted components comprise inhibitory control, working memory, planning and self-management, cognitive flexibility, sustained attention, self-regulation and self-assessment, and goal-directed behavior. These seven components strongly align with the theoretical framework of executive functions, which encompasses self-control, information management, cognitive adaptability, and the regulation of behavior toward goal attainment. Overall, the EFA results confirm a clearly defined seven-component structure, providing a robust empirical foundation for subsequent Confirmatory Factor Analysis (CFA).

Table 4 show Factor summary

Component	Factor Loading
Component 1: Inhibitory Control *Observed Variables*	
- Students are able to regulate their emotions when encountering unexpected situations	.933
- Students are able to wait and comply with classroom rules	.931
- Students are able to stop inappropriate behaviors when reminded by the teacher	.914
- Students do not disturb peers during learning activities	.929
Component 2: Working Memory *Observed Variables*	
- Students are able to remember and accurately follow task procedures	.899
- Students are able to apply prior knowledge to solve new problems	.949
- Students are able to follow multi-step instructions	.938
- Students are able to complete assigned tasks without forgetting essential details	.940
Component 3: Planning and Self-Management *Observed Variables*	
- Students are able to plan their work before beginning tasks	.898
- Students are able to appropriately sequence task procedures	.907
- Students are able to manage their time effectively during activities	.937
- Students are able to prepare necessary learning materials independently	.885
Component 4: Cognitive Flexibility *Observed Variables*	
- Students are able to adjust their thinking or working strategies when encountering obstacles	.892
- Students accept opinions that differ from their own	.917
- Students are able to solve problems using more than one method	.902
- Students are able to learn from mistakes and apply improvements to their work	.916
Component 5: Attention and Focus *Observed Variables*	
- Students are able to maintain sustained attention during learning activities	.931
- Students are not easily distracted during lessons	.956
- Students are able to refocus on tasks after being interrupted	.946
Component 6: Self-Regulation and Self-Assessment *Observed Variables*	
- Students are able to check the accuracy of their work before submission	.903
- Students are able to evaluate their own work according to established criteria	.865
- Students are able to reflect on what they have learned after completing an activity	.914
- Students are able to identify their strengths and areas for improvement	.899
Component 7: Goal-Directed Persistence *Observed Variables*	
- Students do not give up when tasks are difficult or complex	.941
- Students strive to complete tasks in accordance with the goals they have set	.937
- Students are able to complete tasks even when they require extended time	.942

The Exploratory Factor Analysis (EFA) yielded a clearly defined seven-factor structure for executive functions (EF). All observed variables exhibited exceptionally strong factor loadings ranging from .865 to .956, well above the acceptable threshold, indicating robust construct validity and confirming that each item contributed significantly to its respective factor. Specifically, the extracted factors, their loading ranges, and conceptual representations are as follows:

-Inhibitory Control (.914–.933): Reflects learners' ability to regulate their behavior and emotions appropriately in response to situational demands.

-Working Memory (.899–.949): Indicates the ability to retain and process information for problem-solving purposes.

-Planning and Self-Management (.885–.937): Represents the capacity to plan, sequence tasks, and manage work effectively.

-Cognitive Flexibility (.892–.917): Indicates the ability to adapt thinking and employ diverse problem-solving strategies.

-Attention and Focus (.931–.956): Reflects the ability to control attention and maintain focus during task performance.

-Self-Regulation and Self-Assessment (.865–.914): Indicates learners' ability to monitor and reflect on their own learning processes.

-Goal-Directed Persistence (.937–.942): Represents persistence and effort in achieving set goals.

Overall, these seven components provide a comprehensive representation of the EF constructs, aligning seamlessly with the theoretical framework of self-control, information management, cognitive adaptability, and behavioral regulation toward goal attainment. Consequently, the EFA results confirm the instrument's robust structural composition, establishing a solid empirical foundation for subsequent validation via Confirmatory Factor Analysis (CFA).

Part II: Second-Order Confirmatory Factor Analysis (CFA)

1. CFA of the Instructional Management Model

The Confirmatory Factor Analysis (CFA) results demonstrated robust construct validity for the proposed factor model. All indicators exhibited high factor loadings ranging from .786 to .901, well above the acceptable .50 threshold, indicating

strong associations with their corresponding latent constructs. Furthermore, the t-values exceeded 1.96 ($p < .05$), confirming that these factor loadings were statistically significant and that the indicators meaningfully contributed to the latent variables.

Additionally, the coefficients of determination (R^2) ranged from .618 to .814, demonstrating that the indicators explained a substantial proportion of variance in their respective constructs, with values exceeding .70 reflecting particularly strong explanatory power. Overall, the combination of high factor loadings, statistical significance, and strong R^2 values confirms that the developed mathematics instructional model—based on authentic assessment to promote executive functions—aligns well with the empirical data and effectively explains the underlying latent structure.

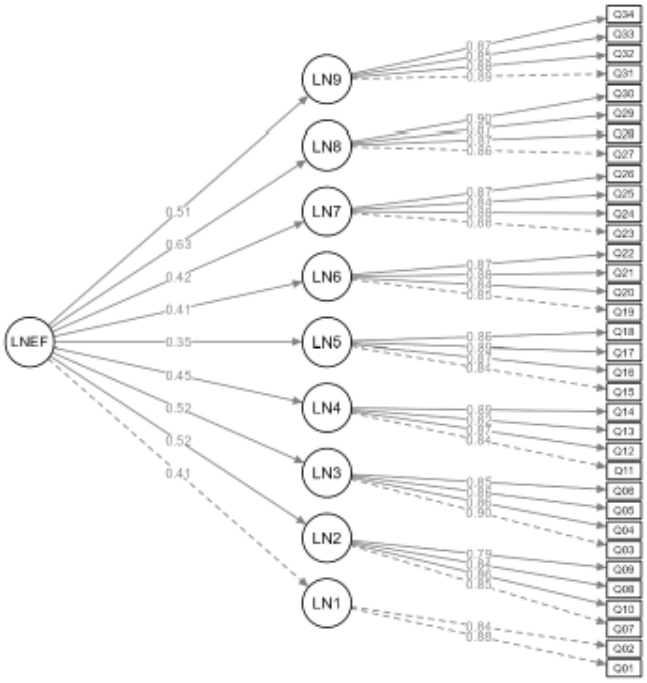
Model fit indices were as follows:

Table 5 Model Fit Statistics of the Second-Order Confirmatory Factor Structure of Mathematics Instruction Emphasizing Authentic Assessment to Promote Executive Function

Statistical Values	Analysis Results
χ^2	1223.00 (p<.001)
df	519
χ^2/df	2.35
RMSEA	0.057
CFI	0.936
TLI	0.931
SRMR	0.070

The goodness-of-fit for the second-order confirmatory factor model was evaluated. Although the chi-square statistic was significant ($\chi^2 = 1223.00$, $df = 519$, $p < .001$)—a common occurrence sensitive to large sample sizes—alternative fit indices were examined to provide a more comprehensive assessment. The relative chi-square (χ^2/df) was 2.35, falling well within the acceptable range (≤ 3). Furthermore, the model demonstrated robust fit across both absolute and incremental indices: The Root Mean Square Error of Approximation (RMSEA) was 0.057 (≤ .06) and the Standardized Root Mean Square Residual (SRMR) was 0.070 (≤ .08). The Comparative Fit Index (CFI = 0.936) and Tucker–Lewis Index (TLI = 0.931) also comfortably exceeded the acceptable .90 threshold, despite being marginally below the more stringent .95 criterion. Collectively,

these indices confirm that the second-order model of mathematics instructional management—based on authentic assessment to promote executive functions among lower secondary students—demonstrates a good fit with the empirical data.



chi-square = 1223.00; df = 519; relative chi-square = 2.35; RMSEA= 0.057; CFI = 0.936; TLI = 0.931; SRMR = 0.070

Figure 2. Second-order confirmatory factor analysis (CFA) model of the authentic assessment-based mathematics learning system.

(Note: LNEF= Mathematics Instructional Management Based on Authentic Assessment to Promote Executive Functions; LN1= Learning objective formulation promoting EF; LN2= Principles of learning activity implementation; LN3= Learning activity management; LN4= Instructional media promoting EF; LN5= Classroom environment promoting EF; LN6= Authentic measurement and evaluation; LN7=Utilization of assessment results for learning improvement; LN8= Post-instructional documentation; LN9= Goal setting and strategic adjustment.)

2. CFA of the Executive Functions Model

The Confirmatory Factor Analysis (CFA) results confirmed the construct validity of the seven-factor measurement model for executive functions (EF). All indicators demonstrated strong associations with their respective latent constructs, yielding high factor loadings ranging from .791 to .907 (well above the .50 threshold).

These loadings were highly significant, with t-values between 18.600 and 23.100 p < .05), confirming their meaningful contribution to the model. Furthermore, the coefficients of determination (R^2) ranged from .626 to .823, indicating moderate to strong explanatory power across the indicators. At the factor level, the seven EF components—inhibitory control, working memory, planning and self-management, cognitive flexibility, sustained attention, self-regulation and self-assessment, and goal-directed behavior—were robustly defined by these significant indicators. Consequently, the EF measurement model exhibits excellent construct validity, making it a reliable and highly appropriate framework for future research and the development of educational measurement instruments.

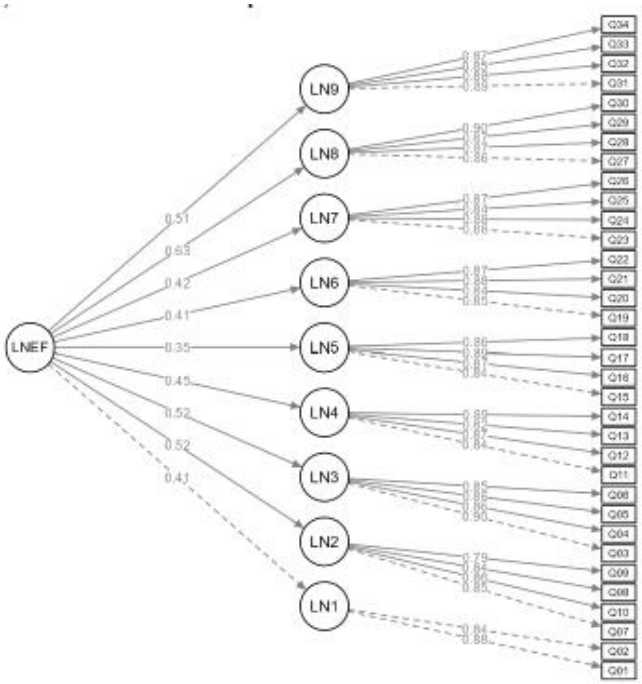
Model fit indices were as follows

Table 5 Model Fit Statistics of the Second-Order Confirmatory Factor Analysis of Executive Functions among Lower Secondary School Students

Statistical Values	Analysis Results
χ^2	1223.00 (p<.001)
df	519
χ^2/df	2.35
RMSEA	0.057
CFI	0.936
TLI	0.931
SRMR	0.070

The goodness-of-fit for the confirmatory factor model of executive functions was comprehensively evaluated. Although the chi-square statistic was significant (χ^2 = 738.00, df = 278, p < .001) due to its known sensitivity to sample size, the relative chi-square (χ^2/df) was 2.65, falling well within the acceptable threshold (≤ 3). Further examination of alternative fit indices demonstrated an acceptable to good overall model fit. Specifically, the Root Mean Square Error of Approximation (RMSEA) was 0.063, and the Standardized Root Mean Square Residual (SRMR) was 0.053, both satisfying their respective acceptable criteria (< .08). Additionally, the Comparative Fit Index (CFI = 0.942) and Tucker–Lewis Index (TLI = 0.932) comfortably exceeded the acceptable .90 threshold, despite being marginally below the stricter .95 cutoff. Collectively, these indices confirm that the measurement model

appropriately represents the latent structure of executive functions among lower secondary students and aligns well with the empirical data.



chi-square = 1223.00; df = 519; relative chi-square = 2.35; RMSEA= 0.057; CFI = 0.936; TLI = 0.931; SRMR = 0.070

Figure 3. Second-order confirmatory factor analysis (CFA) model of the Executive Functions among Lower Secondary School Students

(Note: EFLS= Executive Functions among Lower Secondary School Students; EF1= Inhibitory control; EF2= Working memory; EF3= Planning and self-management; EF4= Cognitive flexibility; EF5= Attention and focus; EF6= Self-regulation and self-monitoring; EF7= Goal-directed persistence.)

Conclusion

The findings confirm that both the instructional management model emphasizing Authentic Assessment and the Executive Functions model possess sound construct validity and structural integrity. The models are empirically supported and suitable for application in promoting Executive Functions among lower secondary students.

Summary of the Study

This study investigated mathematics instructional management emphasizing Authentic Assessment to promote Executive Functions among lower secondary students in Chiang Rai Province. The findings are summarized as follows:

1. Exploratory Factor Analysis (EFA) of Mathematics Instructional Management

The results of the exploratory factor analysis indicated that the Kaiser–Meyer–Olkin (KMO) measure was 0.723 and Bartlett's Test of Sphericity was statistically significant ($p < .001$), demonstrating that the data were suitable for factor analysis. Nine components were extracted, accounting for 87.922% of the total variance. The nine components consisted of: (1) formulation of learning objectives, (2) principles of activity implementation, (3) learning activity management, (4) instructional media, (5) classroom environment, (6) authentic measurement and evaluation, (7) utilization of assessment feedback, (8) post-instructional documentation, and (9) goal setting and strategic adjustment. Factor loadings ranged from 0.867 to 0.951, exceeding the acceptable threshold of 0.40 and were statistically significant at the .01 level, indicating a clear and robust factor structure.

2. Second-Order Confirmatory Factor Analysis (CFA) of the Instructional Management Model

The second-order CFA results showed that the chi-square statistic (χ^2) was 1223.00 ($p < .001$), indicating statistical significance. However, given the sensitivity of the chi-square statistic to large sample sizes and model complexity, additional fit indices were considered. The relative chi-square (χ^2/df) was 2.35, the Comparative Fit Index (CFI) was 0.936, the Tucker–Lewis Index (TLI) was 0.931, the Root Mean Square Error of Approximation (RMSEA) was 0.057, and the Standardized Root Mean Square Residual (SRMR) was 0.070. All indices met acceptable evaluation criteria, indicating that the second-order confirmatory factor model of mathematics instructional management emphasizing Authentic Assessment demonstrated good fit with the empirical data.

3. Exploratory Factor Analysis (EFA) of Students' Executive Functions

The analysis of students' Executive Functions revealed a KMO value of 0.742 and a statistically significant Bartlett's Test ($p < .001$), confirming the suitability of the data for factor analysis. Seven components were extracted, explaining 87.375% of the total variance. These components included: (1) inhibitory control, (2) working memory, (3) planning and self-management, (4) cognitive flexibility, (5) attention and focus, (6) self-regulation and self-assessment, and (7) goal-directed persistence. Factor

loadings ranged from 0.865 to 0.956, all exceeding 0.40 and statistically significant at the .01 level, indicating a well-defined and theoretically coherent structure.

4. Second-Order Confirmatory Factor Analysis (CFA) of Executive Functions

The second-order CFA of students' Executive Functions yielded a chi-square statistic (χ^2) of 738.00 ($p < .001$). Recognizing the sensitivity of chi-square to large sample sizes and complex models, alternative fit indices were examined. The relative chi-square (χ^2/df) was 2.65, the Comparative Fit Index (CFI) was 0.942, the Tucker–Lewis Index (TLI) was 0.932, the Root Mean Square Error of Approximation (RMSEA) was 0.053, and the Standardized Root Mean Square Residual (SRMR) was 0.070. These values satisfied acceptable model-fit criteria, demonstrating that the second-order confirmatory factor model of Executive Functions among lower secondary students exhibited good congruence with empirical data.

Discussions

The findings from the development of a mathematics instructional model emphasizing authentic assessment to promote executive functions (EF) among lower secondary students are synthesized and discussed in relation to the conceptual framework and relevant literature below.

1. Mathematics Instructional Practices and the Structure of Executive Functions

The Exploratory Factor Analysis (EFA) revealed a nine-component structure for mathematics instructional management based on authentic assessment, explaining 87.922% of the cumulative variance. This underscores that such practices operate as an "integrated system," seamlessly encompassing instructional design, activity implementation, assessment, and reflection. Theoretically, this affirms that authentic assessment transcends end-of-instruction evaluation, functioning instead as an embedded "learning mechanism." This aligns with Wiggins (1998) on context-aligned assessment and Black and William (1998) on the critical feedback role of formative assessment. Furthermore, integrating pre-, during-, and post-instructional phases reflects the "assessment as learning" paradigm, fostering learners' active self-regulation.

Regarding executive functions, the EFA identified a seven-component structure explaining 87.375% of the variance. This both aligns with and extends Diamond's

(2013) core EF framework, which comprises working memory, inhibitory control, and cognitive flexibility. The expansion into seven components within the context of mathematics suggests that complex, authentic assessment tasks demand a more integrated and sophisticated application of executive processes. This corroborates findings by Cragg et al. (2017) and Bull and Lee (2014), who identified EF as a critical mechanism underlying success in multi-step mathematical problem-solving.

2. Quality of the Instructional and Measurement Models

The second-order Confirmatory Factor Analysis (CFA) confirmed a robust empirical fit for both the instructional and EF measurement models. Although the chi-square statistic was significant ($p < .001$)—a common artifact of large sample sizes (Hair et al., 2010; Kline, 2016)—all relative and absolute fit indices (e.g., χ^2/df, CFI, TLI, RMSEA, and SRMR) met acceptable thresholds. These results provide strong evidence of the developed model's construct validity.

From an interdisciplinary perspective, this study demonstrates that a mathematics instructional model grounded in authentic assessment systematically functions as a "trigger" for EF development. This occurs through learning environments that inherently demand higher-order cognitive processing. Specifically:

-Rubrics require learners to process and retain multidimensional criteria within their working memory to evaluate their performance against established standards.

-Feedback activates cognitive flexibility, prompting learners to revise strategies when encountering errors or new information.

-Self-assessment directly promotes self-monitoring by necessitating that learners reflect upon, evaluate, and regulate their own learning processes.

These empirical mechanisms align with Clements et al. (2016), who emphasized that contextually grounded activities and continuous reflection are vital for adolescent EF development. Consequently, this study not only confirms the statistical adequacy of the proposed model but also advances theoretical understanding. It provides concrete evidence that authentic assessment operates as a highly effective, active mechanism for cultivating executive functions alongside mathematical competencies in lower secondary students.

Recommendations

Recommendations for Practical Implementation

1. Implementation of the Model in Classroom Practice

Given that the developed instructional model comprises nine essential components, educational institutions and lower secondary mathematics teachers—particularly within the context of Chiang Rai Province and similar settings—should adopt these nine components as a conceptual framework for designing lesson plans. Special emphasis should be placed on the utilization of assessment feedback and goal setting with strategic adjustment, as these processes are central to Authentic Assessment. They play a critical role in stimulating students' self-regulation and self-evaluation, which constitute core dimensions of Executive Functions.

2. Design of Mathematics Assessment and Evaluation

Teachers should reduce reliance on multiple-choice assessments that primarily measure rote memorization and instead design authentic performance tasks or mathematics projects connected to real-life contexts. Scoring rubrics should be constructed to assess two parallel dimensions: (1) the accuracy and rigor of mathematical processes, and (2) behavioral indicators of the seven Executive Function components. For example, cognitive flexibility may be evaluated when students employ novel or alternative strategies to solve complex mathematical problems

Recommendations for Future Research

1. Experimental Research to Examine Effectiveness

As the present study focused on model development and validation of construct validity using advanced statistical techniques (CFA), subsequent research should implement the developed mathematics instructional model emphasizing Authentic Assessment in actual classroom settings. A quasi-experimental research design should be employed to compare students' Executive Function development before and after the intervention. Such an approach would provide stronger empirical evidence regarding the model's effectiveness.

2. Investigation of Measurement Invariance

Future studies should examine the measurement invariance of both the Executive Functions model and the instructional management model across diverse

contextual groups. For instance, comparisons may be conducted between students in large and small schools, or between groups with differing levels of mathematics achievement. This would strengthen the generalizability and robustness of the instruments for broader application across varied educational contexts.

Acknowledgment

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Enhancing Cost Efficiency in Cold Chain Logistics Services: A Performance Comparison between Experience-Based Routing and Excel Solver Optimization

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Abstract

In the cold chain logistics industry, maintaining product integrity through precise temperature control and timely delivery is paramount. However, many Small and Medium Enterprises (SMEs) continue to rely on subjective, experience-based routing—a heuristic approach that often leads to sub-optimal paths and inflated operational costs. The objectives of this study were: 1) to analyze and document empirical experience-based routes used by drivers; 2) to develop a mathematical optimization model specifically for cold chain logistics using Excel Solver; and 3) to evaluate the performance gap between manual intuition and algorithmic solutions to quantify potential efficiency gains. The research utilized purposive sampling of five empirical delivery routes as the primary sample from a distribution plant in Pathum Thani. The research tools included manual driver logs and Microsoft Excel Solver utilizing the Simplex LP algorithm. Data were collected by documenting distances from experienced drivers to establish a baseline, which were then analyzed through a comparative performance gap analysis against the mathematical model to identify efficiency improvements. The research results are as follows: 1) Algorithmic optimization consistently outperformed human heuristic decision-making in 80% of the tested cases (Routes 1, 3, 4, and 5); 2) The most significant efficiency gain was recorded in Route 1, where the total distance was reduced by 9.5%, decreasing from 95 to 86 units; and 3) While driver intuition reached the mathematical optimum in one instance (Route 2), the overall findings indicate that human experience is inconsistent across complex scenarios compared to systematic optimization. The study concludes that integrating a systematic routing tool like Excel Solver enables measurable reductions in mileage and fuel

consumption. For SMEs, this represents a viable, low-cost digital transformation strategy that strengthens both cost-efficiency and product quality retention in cold chain operations.

Keywords: Cold Chain Logistics, Vehicle Routing Problem (VRP), Excel Solver, Experience-Based Routing, Cost Efficiency

Background and Statement of the problem

In the modern food industry, the demand for fresh and frozen products has led to the rapid growth of Cold Chain Logistics. Unlike standard delivery services, cold chain logistics requires maintaining a specific temperature range throughout the entire transportation process to ensure food safety and quality. Any delay in the delivery schedule directly impacts on the perishability of the products, leading to financial losses and potential health risks for consumers.

Efficient Vehicle Routing Problem (VRP) management is the backbone of cold chain operations. In many small to medium-sized enterprises (SMEs), route planning is still conducted through Manual Experience (Experience-Based Routing). While this method relies on the local knowledge of drivers, it often lacks the precision needed to handle complex variables such as traffic fluctuations, multiple delivery windows, and fuel consumption optimization.

The primary challenge in cold chain delivery is the high operational cost associated with specialized refrigerated vehicles and the strict time constraints required to prevent spoilage. Relying on human intuition for route planning often results in sub-optimal paths, leading to unnecessary mileage, higher fuel expenses, and increased "open-door" frequency, which compromises temperature integrity.

There is a critical need for an accessible, cost-effective computational tool that can assist businesses in optimizing their routes without the need for expensive, high-end logistics software. Microsoft Excel Solver (in brief Excel Solver), a powerful optimization add-in, offers a potential solution by using mathematical algorithms to find the most efficient routes. However, its effectiveness compared to traditional manual methods—specifically within the rigorous demands of cold chain services—remains a subject that requires empirical validation.

This research aims to bridge the gap between traditional delivery practices and mathematical optimization. By conducting a performance comparison, this study evaluates whether Excel Solver can significantly enhance cost efficiency and reduce delivery times in cold chain logistics. The findings will provide local food delivery businesses with a data-driven framework to minimize operational costs while maintaining the high standards of the cold chain.

Objective

1. To analyze and document current experience-based routing: To investigate the existing delivery paths chosen by drivers in a cold chain logistics service, identifying the patterns and distances resulting from manual, experience-based decision-making.

2. To develop an optimization model using Excel Solver: To design a mathematical model specifically for cold chain logistics that minimizes transportation costs and distances while adhering to strict delivery time-windows.

3. To evaluate the performance gap between manual and optimized routing: To conduct a comparative analysis of the results from Step 1 and Step 2, quantifying the potential for cost reduction and efficiency gains through the use of Excel Solver.

Expected benefits

1. For the Logistics Service Provider

• Operational Cost Reduction: The company can identify specific opportunities to reduce fuel consumption and vehicle wear-and-tear by adopting mathematically optimized routes.

• Enhanced Time Management: By minimizing travel time, the company can improve its "on-time delivery" rate, which is a critical performance metric in cold chain services.

• Improved Resource Utilization: The study will demonstrate how to better allocate drivers and vehicles, potentially allowing the company to handle more deliveries with the same fleet size.

2. For Cold Chain Integrity and Quality Control

• Minimized Spoilage Risk: Efficient routing reduces the time products spend in transit, thereby maintaining the "thermal envelope" and ensuring that perishable goods reach customers in optimal condition.

• Consistency in Service: Shifting from subjective driver intuition to an algorithmic model ensures a more predictable and standardized delivery schedule, regardless of which driver is assigned to the route.

3. Academic and Practical Contributions

• Validation of Low-Cost Tools: This study will prove that SMEs (Small and Medium Enterprises) do not need expensive, specialized software to optimize their logistics; a standard tool like Excel Solver can provide significant value.

• Baseline for Future Research: The comparative data between manual and optimized routing can serve as a foundation for more complex studies involving real-time GPS tracking or multi-depot cold chain problems.

Conceptual Framework

1. Vehicle routing problem (VRP)

The Vehicle Routing Problem (VRP) is a well-established optimization challenge with a 40-year history (Pitakaso, 2017). Its enduring relevance stems from the ability to incorporate complex, real-world variables into the model. Key research includes the management of logistics for multi-terminal pickup and delivery (Nagy & Salhi, 2005), and the implementation of time-window constraints within multi-trip transportation frameworks (Nueangnitnaraporn & Karoonsoontawong, 2018). Additionally, the inclusion of stochastic demands (Dror et al., 1989) and time-restricted freight pickups (Solomon, 1983) further complicates the model, requiring more sophisticated decision-making tools to find efficient solutions.

2. Transportation cost

According to established logistics principles, transportation expenditures are primarily driven by four key determinants: density, distance, storage, and volume (Bowersox & Closs, 1886). As illustrated in Figure 1, there is a direct correlation between distance and total logistics costs, where increasing travel spans lead to a proportional rise in transportation outlays.

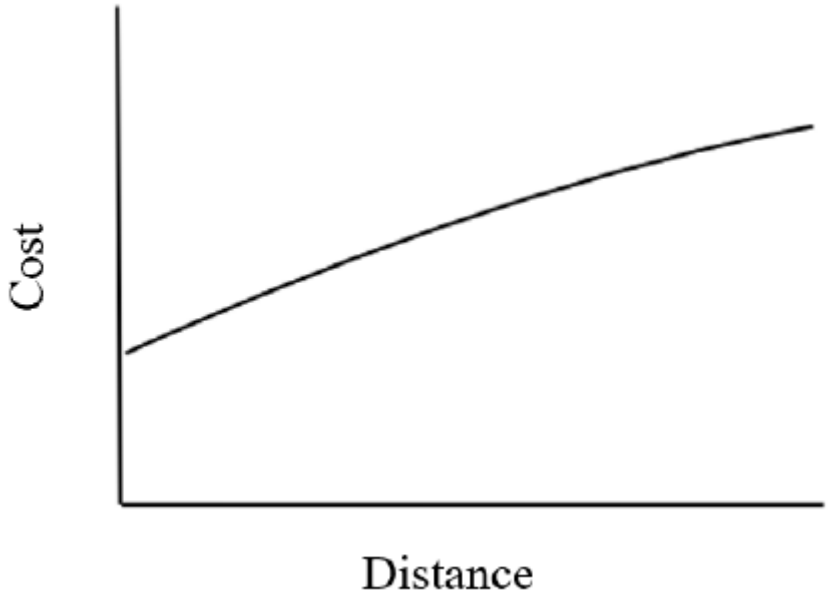


Figure 1 The relationship between distance and transportation cost

3. Microsoft Excel Solver

Linear Programming (LP) serves as a fundamental technique within operations research, widely adopted by scientists, engineers, and decision-makers for resolving resource allocation challenges. These challenges typically involve managing finite assets—such as capital, time, labor, and raw materials—under specific constraints of scale or volume. The primary objective of LP is to achieve an optimal outcome, such as maximizing profits or minimizing operational expenditures, under the assumption of linear relationships between variables (Srinual,2016). Within the scope of this study, LP is utilized via Excel Solver, a versatile optimization tool integrated into Microsoft Excel.

The management of cold chain logistics is significantly more complex than standard dry cargo logistics due to the sensitivity of the products involved. According to Smith (2021), the primary objective of a cold chain is to preserve the physical and chemical properties of perishable goods from the point of origin to the final consumer. However, several critical challenges hinder the efficiency of this process.

4. Challenges in Cold Chain Logistics

Perishability and Product Integrity: The most fundamental challenge is the inherent perishability of the goods, such as fresh produce, dairy, and pharmaceuticals.

Unlike general commodities, these products have a limited shelf life that is directly affected by environmental conditions. Gupta and Kerr (2020) emphasize that any delay in the transportation cycle accelerates the rate of spoilage, leading to significant "food loss" and financial deficits. In a study by Rong et al. (2011), it was noted that the quality of food products degrades exponentially relative to the duration of exposure to sub-optimal temperatures, making "time-efficiency" the most critical factor in route planning.

Temperature Fluctuations and Technical Barriers: Maintaining a "constant temperature environment" is a significant technical hurdle. Rodrigue (2020) argues that the "last mile" of delivery is the most vulnerable segment of the cold chain. Frequent door openings during multiple delivery stops lead to temperature fluctuations inside the refrigerated container, which can compromise the entire batch of products. Furthermore, James and James (2010) highlight that equipment failure or poor insulation in older vehicle fleets—often found in SMEs—increases the risk of "thermal shocks," where products are exposed to ambient air, leading to bacteria growth and safety hazards.

High Operational and Energy Costs: Cold chain operations are energy-intensive and costly. Tassou et al. (2012) found that refrigerated transport can consume up to 20% more fuel than standard transport due to the power required to run the Transport Refrigeration Unit (TRU). This creates a conflict between maintaining high-quality service and achieving cost efficiency. Consequently, as noted by Bogataj et al. (2005), optimization of the Vehicle Routing Problem (VRP) is not merely a logistical preference but a financial necessity for cold chain providers to remain competitive in a low-margin market.

5. Related work

Extensive research has been conducted to optimize vehicle routing across various industries (Komutpun, 2013). For instance, Excel Solver was successfully implemented to enhance the efficiency of waste management logistics. In terms of construction materials, Chaiwongsakda et al., (1989) applied the Savings Algorithm to optimize brick delivery routes within the Bangkok Metropolitan Region. More advanced approaches, such as Evolutionary Algorithms, were utilized in (Maneengam et al.,1989) and Wajanawichakon & Srisurin (2019) to address complex garbage collection scenarios under varying conditions. Furthermore, comparative studies have been used to validate

optimization tools; for example, Sawangyat (2018) evaluated Excel Solver against the Greedy Algorithm and traditional experience-based methods for tourism routing. Other methodologies, such as the Clarke-Wright Savings method for national freight (Pichpubul & KaewThumchai, 2012) and a comparison between the Clustering-Locating-Routing technique and the Sweep Algorithm for medical device maintenance (Supakdee et al.,1989), further demonstrate the diverse landscape of VRP optimization.

The existing body of literature demonstrates that VRP research is highly contextual, with constraints and conditions tailored to specific operational scenarios. These problems are typically addressed using either bespoke algorithms or accessible commercial tools such as Excel Solver. Consequently, this study employs both a Greedy Algorithm and the Linear Programming (LP) capabilities of Excel Solver to address an identical VRP case, providing a rigorous comparison of their respective performances.

Conceptual Framework

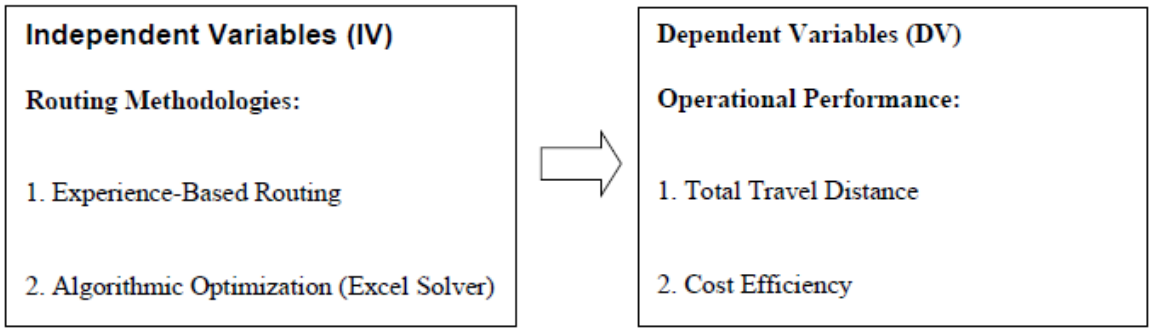


Figure 2 Conceptual Framework of the Study

As illustrated in Figure 2, the conceptual framework of this research is structured to evaluate the causal relationship between routing methodologies and operational outcomes. The Independent Variables consist of two distinct approaches: 1) Experience-Based Routing, which relies on subjective human intuition and historical familiarity; and 2) Algorithmic Optimization via Excel Solver, which utilizes the Simplex LP engine for mathematical precision. The framework posits that the choice of methodology directly impacts the Dependent Variables, specifically the Total Travel Distance (spatial efficiency) and Cost Efficiency (financial impact). This is particularly critical in Cold Chain

Logistics, where reduced distance leads to shorter transit times, thereby maintaining product integrity and reducing fuel consumption associated with refrigerated transport.

Research Methodology

1. Research Design

This study employs a quantitative research design, specifically a comparative experimental approach to evaluate logistical efficiency. This framework allows for a precise measurement of the performance gap between manual intuition and algorithmic solutions by converting empirical delivery operations into measurable datasets.

2. Population and Sample

The population of this study encompasses the total network of temperature-controlled delivery routes managed by a specialized cold chain logistics provider in Pathum Thani, Thailand. Given the resource-intensive nature of cold chain operations and the need for high-precision data, a purposive sampling technique was strategically employed to select the research sample.

The study focused on five primary delivery routes that were selected based on a rigorous set of criteria to ensure they represent the core operational challenges of the firm:

- **High Operational Frequency:** These routes are executed daily or on a consistent weekly basis, ensuring that any identified efficiencies would have a significant cumulative impact on annual operational costs.
- **Structural Complexity**: Each selected route involves multiple delivery nodes (destinations), providing a sufficient level of complexity to test the limitations of human heuristic decision-making against mathematical algorithms.
- **SME Operational Context:** The routes mirror the typical constraints of Small and Medium Enterprises, such as limited fleet size and strict customer time-windows, making the findings highly applicable to the industry.

This sampling strategy ensures that the collected data is both representative of daily operations and sufficiently complex to test the optimization model's limits. Consequently, these five routes provide a robust and representative dataset for a

meaningful quantitative comparison between traditional experience-based paths and the proposed optimized solutions.

3. Research Tool

The tools utilized in this quantitative research consist of both empirical data collection instruments and mathematical software:

• **Manual Route Logs:** Historical data and GPS records from experienced drivers were used to document the "Experience-Based Routing" baseline. This represents the heuristic decision-making process currently used by the firm.

• **Microsoft Excel Solver:** The primary optimization engine used to develop the Linear Programming (LP) model. This study specifically utilizes the **Simplex LP algorithm** to find the global optimum for distance minimization.

• **Conceptual Framework:** A systematic model (Independent vs. Dependent variables) used to guide the analysis and ensure all operational constraints, such as time-windows and set-point temperatures, are accounted for.

4. Data Collection and Analysis

Data were collected and analyzed through a systematic four-step process:

• **Data Acquisition:** Documenting the actual distances traveled by drivers for the five selected routes over a one-month period to establish a baseline.

• **Distance Matrix Construction:** Building a comprehensive matrix of all possible distances between the distribution plant and the target delivery nodes using digital mapping tools such as Google Maps Distance Matrix API to ensure accuracy.

• **Optimization Simulation:** Inputting the matrix data into the Excel Solver LP model to generate the mathematically shortest possible routes while adhering to delivery constraints.

• **Performance Gap Analysis:** Using descriptive statistics to compare the results from the manual and optimized methods. The analysis focuses on calculating the percentage of distance reduction and the potential fuel cost savings, providing a clear quantitative measure of the Solver's effectiveness.

The research framework is structured into three primary phases to systematically evaluate the efficiency of cold chain routing, as illustrated in the procedural flow in Figure 3.

First Step, Data Acquisition and Manual Route Documentation: The initial phase involves conducting structured inquiries with the logistics drivers. This step captures the actual routes utilized during daily operations, which are formulated based on Experience-Based Routing (human intuition and local knowledge).

Step 2, computational optimization via Excel Solver: In the second phase, the same delivery parameters—including origin points, destinations, and specific cold chain constraints—are modeled within Excel Solver. The Linear Programming (LP) engine is employed to determine the mathematically optimal routes aimed at minimizing total distance or cost.

Next step, comparative Performance Analysis: The final phase involves a rigorous comparison between the results obtained from manual planning and the algorithmic output of Excel Solver. The comparison focuses on key performance indicators (KPIs) such as total mileage, travel time, and estimated fuel consumption to quantify the optimization gap.

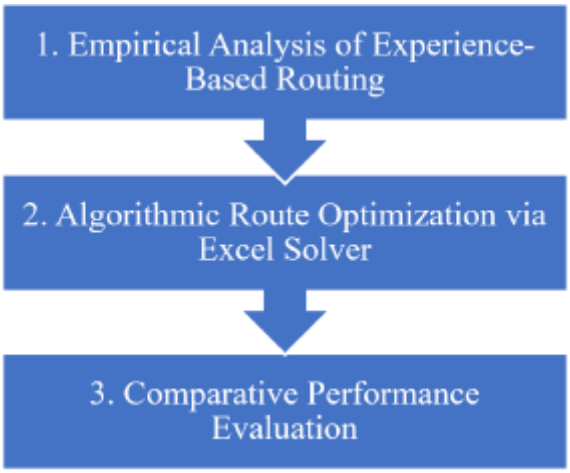


Figure 3 The Methodology of this research

The preliminary stage of this research involved documenting five unique delivery routes executed by five different drivers. These transit paths were determined by the drivers' professional intuition and heuristic judgment, lacking any formal algorithmic optimization. A representative example of such a route is illustrated in Figure 4, where Node A serves as the original plant and Node D as the customer destination. Intermediate waypoints, such as intersections or bridges, are denoted as Nodes B and C. The values assigned to the arcs between these nodes represent the physical distance of

each segment. In this manual model, drivers navigate the network autonomously, relying exclusively on their field experience to select their path.

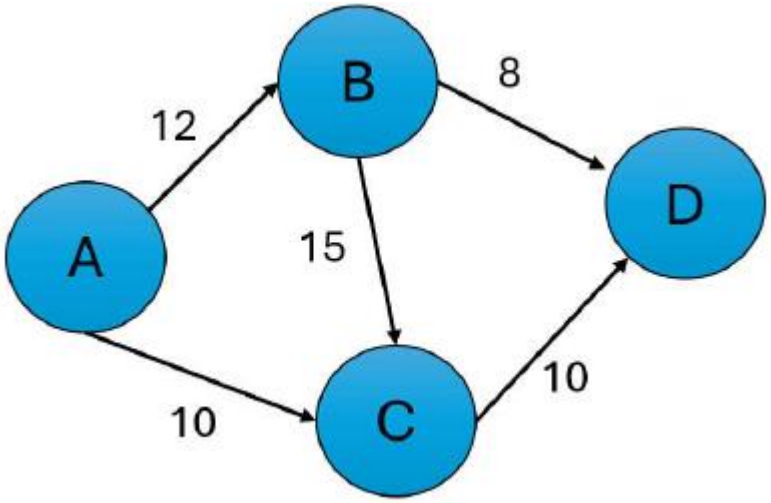


Figure 4 One of the delivery cases

The second phase of the methodology involves solving the routing problem identified in the previous step using the Excel Solver optimization engine. To execute this, it is necessary to establish a system of linear equations that represent the network flow—specifically the 'inflow' and 'outflow' of each node.

The following variables were defined to construct the mathematical model:

- Xi,j is the distance between town i and j.
- Flow_in and Flow_out are the distance between the in- and out-road.
- For the start and destination towns, Flow_in – Flow_out = 1.

For the other towns, Flow_in – Flow_out = 0.

	A	B	C	D	E	F	G
1	**Point**	**Equation**	**From**	**To**	**Distance**	**Symbol**	**Result**
2	A	=G2+G3	1	2	12	X12	
3	B	=G5+G4-G3	1	3	10	X13	
4	C	=G6-G3-G5	2	4	8	X24	
5	D	=G4+G6	2	3	15	X23	
6			3	4	10	X34	
7							

Figure 5 Example of the equations created for the route case

Following the model setup, the Excel Solver parameters were configured as follows: The Objective Function was set to 'Minimize' to identify the shortest possible transit distance. The operational constraints were then integrated into the system as illustrated in Figure 6. Finally, the Simplex LP engine was selected as the optimization algorithm, rendering the model ready for execution.

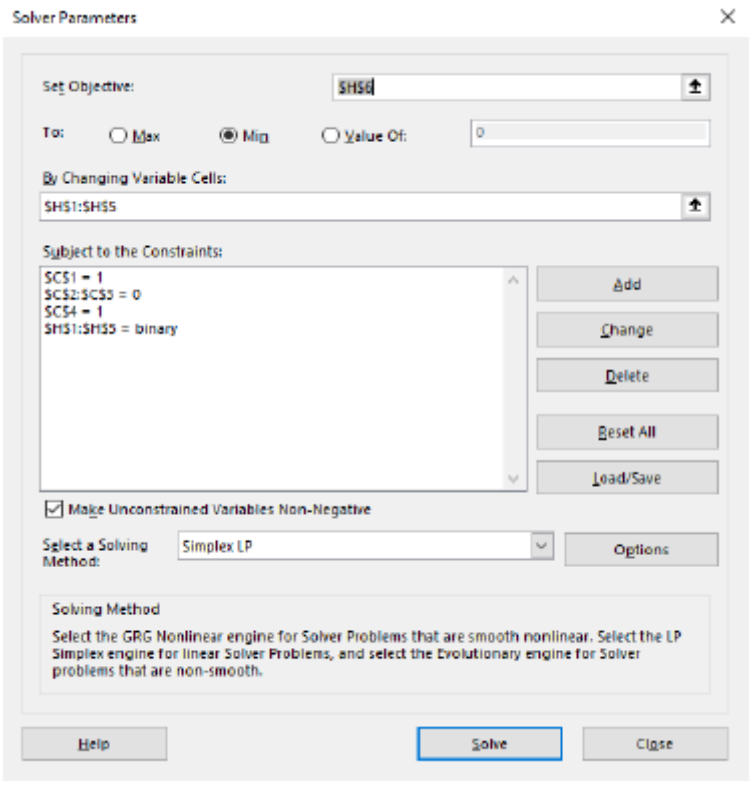


Figure 6 Solver Parameter Settings for Linear Programming Optimization

The final phase of the methodology involves a comparative performance analysis between the heuristic routes derived from driver experience and the optimal solutions generated by Excel Solver. By evaluating these two approaches across all case studies, the research quantifies the efficiency gap and identifies the superior routing strategy. A comprehensive analysis and interpretation of these findings are presented in the subsequent Results and Discussion section.

Research Results

The results of this study are presented in accordance with the three research objectives to demonstrate the transition from manual heuristics to mathematical optimization.

1. Results of Current Experience-Based Routing Analysis

The initial phase of the study documented the baseline performance of the logistics provider's current operations. Based on historical driver logs for the five selected routes, it was found that routing decisions were primarily driven by individual driver intuition. The total distances recorded for these empirical routes were used as the benchmark for comparison. The data revealed that while drivers could navigate effectively, their paths often lacked geographical efficiency, particularly in routes with more than four delivery nodes.

2. Development of the Excel Solver Optimization Model

Following the documentation of manual routes, a mathematical model was successfully developed using Microsoft Excel Solver. By inputting the distance matrix obtained from the Google Maps Distance Matrix API and applying the Simplex LP algorithm, the model generated optimized delivery sequences. The model adhered to all operational constraints, including the distribution plant's location and specific customer delivery windows, proving that a low-cost, standard software tool can effectively solve complex cold chain routing problems.

3. Comparative Performance and Efficiency Gains

The final objective was met by comparing the manual distances against the optimized distances generated in Step 2. The comparative results are summarized in Table 1 below:

Table 1 Comparative Analysis of Total Distances: Empirical Driver Routes vs. Excel Solver Optimization and Resulting Variance.

Route	Driver's experience	Excel Solver	Difference	%
1	95	86	9	9.49
2	115	115	0	0.00
3	80	76	4	5.00
4	102	99	3	2.94
5	65	64	1	1.54

As indicated in Table 1, the Excel Solver successfully optimized the trajectories for Routes 1, 3, 4, and 5, yielding shorter distances than those determined by driver experience. The most significant improvement was observed in Route 1, which achieved a 9.47% reduction in total mileage. For Route 2, the solver matched the driver's performance, indicating that human intuition can occasionally reach the global optimum in simpler or highly repetitive paths. Overall, these reductions in mileage directly correlate with decreased fuel consumption and lower operational expenses, offering the logistics provider a clear pathway toward enhanced cost-efficiency and accelerated delivery lead times.

Summary of the Study

This research evaluated the efficiency of cold chain logistics by comparing experience-based driver routing with mathematical optimization using Excel Solver. The study analyzed five distinct delivery routes originating from a distribution plant in Pathum Thani.

The results, consolidated in Table 1, demonstrate that algorithmic optimization consistently outperformed human intuition. Specifically, the Excel Solver identified shorter trajectories in 80% of the cases (Routes 1, 3, 4, and 5). While Route 2 showed that driver experience can occasionally reach the mathematical optimum, the overall data reveals a significant "optimization gap." For instance, in Route 1, the Solver reduced the distance from 95 to 86 units, representing a substantial improvement in spatial efficiency.

The study concludes that integrating a systematic routing tool allows for a measurable reduction in mileage, which directly supports the primary goals of cold chain management: minimizing transportation costs and ensuring product freshness through reduced transit times.

Discussions

The findings of this research provide a clear roadmap for practical application within the logistics sector. Following the research objectives, the results can be discussed as follows:

1. Analysis of Current Experience-Based Routing

The investigation into existing delivery paths (Step 1) revealed that drivers rely heavily on "Heuristic" or intuitive decision-making. While this experience-based approach is often perceived as reliable, the data showed that it lead to sub-optimal paths in 80% of the studied cases. This suggests that "subjective" routing is limited by human cognitive capacity when dealing with multiple nodes. By documenting these empirical routes, the study establishes a baseline that highlights the inconsistency of performance across different drivers, regardless of their individual seniority or familiarity with the area.

2. Development and Utility of the Excel Solver Optimization Model

The successful design of a mathematical model specifically for cold chain logistics (Step 2) proves that complex Vehicle Routing Problems (VRP) can be addressed using accessible technology. A critical point for discussion is that Microsoft Excel Solver—a standard office application—is a powerful enough engine to minimize transportation distances while adhering to strict constraints. For Small and Medium Enterprises (SMEs) in Thailand, this demonstrates that digital transformation in logistics does not require a large capital investment in expensive, specialized software, making high-level optimization reachable for smaller firms.

3. Evaluation of the Performance Gap and Efficiency Gains

The comparative analysis (Step 3) between manual and optimized routing quantified a significant performance gap, most notably the 9.5% distance reduction in Route 1. This "multiplier effect" translates into two major impacts:

• Economic Impact: Lower mileage directly results in lower fuel costs and reduced vehicle maintenance, which are vital for the survival of SMEs.

• Cold Chain Quality Impact: In cold chain logistics, "time is the greatest enemy." The shorter routes generated by the model decrease the window of risk for temperature fluctuations. According to the results, systematic optimization not only protects the quality of perishable goods but also minimizes carbon footprints through reduced fuel consumption, strengthening both cost-efficiency and product integrity.

Recommendations

1. Implementation of Standardized Routing

The company should move away from relying solely on driver intuition for route selection. It is recommended that management provides pre-calculated, optimized route maps generated via Excel Solver to all drivers to ensure consistent fuel efficiency and timing.

2. Investment in Low-Cost Digital Tools

Since the study proves the effectiveness of MS Excel Solver, the company does not need to invest in expensive proprietary software immediately. Instead, they should train logistics staff in basic Linear Programming and solver tools to handle changing delivery locations dynamically.

3. Fuel and Maintenance Monitoring

The company should conduct a three-month pilot program using the optimized routes from this study to track the actual reduction in fuel consumption and vehicle wear-and-tear. This data would provide a clear Return on Investment (ROI) for optimization efforts.

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Exporter Exposure to Indonesia's 2026 Rice Import Ban: Evidence from Trade Concentration and Dependence Ratios

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Abstract

The Indonesian government has announced a suspension of rice imports starting in 2026, marking a shift away from its historical reliance on imports to stabilize domestic supply and prices. Using annual data from 2017–2024, this study applies descriptive statistics, high- and low-import year comparisons, correlation analysis between import volumes and import unit values (IUV), and Exporter Dependence Ratios (EDR) to assess exporter exposure to the loss of the Indonesian market. Results show that imports are highly volatile but increasingly concentrated, with Thailand and Vietnam dominating recent high-import periods, while India, Pakistan, and Myanmar display more variable participation. High EDR values for Myanmar, Thailand, and Vietnam indicate substantial dependence on Indonesian demand. The findings suggest that the 2026 import ban may create significant adjustment pressures for these exporters while removing a key external mechanism that previously helped stabilize Indonesia's domestic prices.

Keywords: Rice trade; import ban; exporter exposure; ASEAN market

Background and Statement of the problem

In Indonesia, rice policy has long been involved in active state intervention. The National Logistics Agency (BULOG), established in 1968, was mandated to protect domestic markets from violent swings in price and manage nationwide warehouses to maintain public rice stocks. Through floor and ceiling price mechanisms and centralized control over imports, BULOG has historically imported rice during supply shortfalls and released stocks to stabilize markets (Gérard, 2010). Empirical time-series evidence

indicates that higher import values are associated with lower retail rice prices, suggesting that imports have functioned as a complementary mechanism for price stabilization during supply shortfalls (Antriyandarti et al., 2024).

Global rice exports are highly concentrated among a small number of major suppliers, particularly India, Thailand, and Vietnam (Greenville, 2018; USDA, 2023). India tops in rice exporting and is the world's largest rice exporter. As a result, policy changes in India have shown significant impacts on global rice prices and trade flows (USDA, 2023). Within Southeast Asia, Thailand and Vietnam take the role of key regional exporters by supplying some deficit markets such as Indonesia and the Philippines (Fadah et al., 2024).

Within this global exporting structure, Indonesia participates as a periodic net importer, with import volumes rising during episodes of domestic supply tightness, as documented in official trade statistics and recent empirical evidence (Antriyandarti et al., 2024). Import-demand estimates using an Almost Ideal Demand System (AIDS) framework indicate that rice imports from Thailand and Vietnam are relatively price inelastic, showcasing Indonesia's importance as a destination market within the regional rice system (Widarjono, 2018).

Figure 1 from USDA presents export price trends for Thailand, Vietnam, and India from 2013 to 2023. The three major exporters display closely aligned price movements and substantial volatility in 2023.



Figure 1 Rice Export Price Trends for Thailand, Vietnam, and India (2013-2023)

Source: United States Department of Agriculture (USDA)

When it comes to rice imports, Indonesia temporarily paused imports or reduced them when domestic supplies were adequate in earlier years, reflecting adjustments to changing supply conditions (VNA/The Investor, 2025). Thus, a complete no-import policy for 2026 represents a meaningful drift in policy direction.

The pie chart below summarizes the average structure of Indonesia's rice import sources over 2017–2024, highlighting the dominance of Thailand, Vietnam, Pakistan, India, and Myanmar in supplying the Indonesian market. It visually confirms that Thailand holds the largest average share, followed by Vietnam and Pakistan, while smaller suppliers such as Japan, China, and "Others" contribute only marginally to total imports. The figure therefore illustrates the concentrated nature of Indonesia's rice import dependence on a small group of regional exporters, providing background for later analysis of how the 2026 import ban may affect these trading partners.

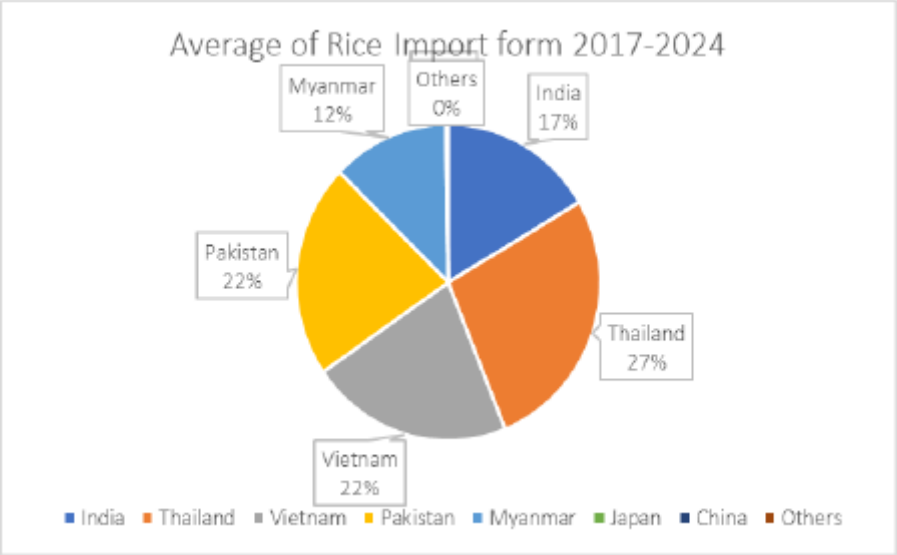


Figure 2 Average rice import of Indonesia (2017-2024)

Source: Author Calculation based on Statistic Indonesia and WITS

At the same time, Indonesia's rice policies have caused partial insulation from international markets. Although such policies have resulted in reduced sudden domestic price spikes, they have also helped weaken the transmission of international prices into the domestic market and maintained price gaps relative to world markets (Rosner & McCulloch, 2008; Patunru & Ilman, 2019). Trade restrictions and policy interventions

across ASEAN similarly shape regional price transmission and volatility (Greenville, 2018; Fadah et al., 2024).

Indonesia is removing an important tool for stabilizing rice prices and at the same time closing a major market for exporters. However, the consequences for exporting countries and domestic rice prices have not been clearly examined using recent data. This study therefore explores how the 2026 import ban may change trade relationships and price stability.

Objective

1. To describe Indonesia's rice import patterns from 2017–2024
2. To examine associations between import volumes and average import prices (IUV)
3. To identify which major exporting countries appear most exposed to Indonesia's 2026 import ban

Expected benefits

This research is expected to:

- Provide a clearer understanding of Indonesia's historical rice import patterns and supplier structure.
- Support the future discussions on the results of the import ban on rice by the Indonesian government

Research Methodology

This study uses descriptive statistical analysis to examine historical rice import patterns and exporter exposure prior to the 2026 import ban. The population comprises all annual rice import transactions from Indonesia from 2017 to 2024, as recorded in Statistics Indonesia (BPS). The sample consists of the complete annual aggregate import volumes (net-weight in tons) by country of origin for the eight-year period 2017–2024. No sampling was applied; the study uses the full available census data from this timeframe. The sample includes 8 annual observations (one per year, 2017–2024), yielding 64 country-year records (8 years × 8 major origin countries). The primary variables collected

are: Year (2017–2024), Country of origin (India, Thailand, Vietnam, Pakistan, Myanmar, Japan, China, Others), Net-weight imported (tons), Total annual import volume (tons), Import unit value (IUV, US$/ton, derived as total value / total tons where available). Data were obtained from BPS (Statistics Indonesia) Statistical Yearbook and secondary world export totals for calculating Exporter Dependence Ratio (EDR) were sourced from United States Department of Agriculture (USDA) annual reports and World Integrated Trade Solution (WITS). Annual shares (%) were calculated as (country tons / total tons) × 100. Descriptive statistics (mean, std dev, min, max, percentiles, CV) were computed per country and per group (high/low import years). High-import years were defined as total >1 million tons (2018, 2023, 2024). Welch's t-tests (unequal variances) compared means between groups. Pearson and Spearman correlations examined volume-IUV relationships. Visualizations and EDR were generated in Excel.

To evaluate structural differences in pricing and sourcing behavior, the study period (2017–2024) was partitioned into high-import (n=3) and low-import (n=5) years. Given the small and unequal sample sizes, Welch's Two-Sample t-test was employed to compare mean Import Unit Values (IUV), as it remains robust without assuming equal variances or homogeneity, thereby reducing Type I error risks. Additionally, the relationship between import volumes and prices was analyzed through a dual-correlation framework: Pearson's (r) was used to measure linear strength and direction, while Spearman's (ρ) captured potential non-linear monotonic relationships. This comprehensive approach allows for a more nuanced interpretation of Indonesia's price sensitivity and adjustment mechanisms during supply shocks.

Research Results

Indonesia's rice imports from 2017 to 2024 displayed high year-to-year volatility and concentration among a few suppliers (Table 1). Total volume ranged from 305,275 tons (2017) to 4,519,421 tons (2024), with three years exceeding 1 million tons (2018, 2023, 2024) classified as high-import periods. Thailand and Vietnam dominated recent high years, supplying over 2 million tons combined in 2023 and 2024, while earlier low-import years showed more dispersed sourcing across Pakistan, Myanmar, and India.

These patterns highlight Indonesia's increasing reliance on regional suppliers, particularly Thailand and Vietnam.

Table 1 Annual Rice Import Volumes by Country of Origin, 2017–2024 (Netweight in Tons)

Country of Origin	2017	2018	2019	2020	2021	2022	2023	2024
India	32,209.7	337,999.0	7,973.3	10,594.4	215,386.5	178,533.6	69,715.7	246,587.9
Thailand	108,944.8	795,600.1	53,278.0	88,593.1	69,360.0	80,182.5	1,381,921.2	1,364,232.8
Vietnam	16,599.9	767,180.9	33,133.1	88,716.4	65,692.9	81,828.0	1,147,705.3	1,248,245.0
Pakistan	87,500.0	310,990.0	182,564.9	110,516.5	52,479.0	84,407.0	309,309.7	803,844.7
Myanmar	57,475.0	41,820.0	166,700.6	57,841.4	3,790.0	3,830.0	141,204.0	831,379.0
Japan	72.1	0.2	90.0	0.3	230.3	56.1	61.5	100.7
China	2,419.0	227.7	24.3	23.8	42.6	6.0	7.0	19.3
Others	54.3	6.5	744.6	0.3	760.1	364.1	12,933.3	25,011.2
Total	**305,274.8**	**2,253,824.4**	**444,508.8**	**356,286.2**	**407,741.4**	**429,207.3**	**3,062,857.6**	**4,519,420.6**

Source: BPS Statistical Yearbook, Indonesia.

Table 2 Descriptive Statistics of Rice Import Shares (%) by Country of Origin, 2017–2024

Country of Origin	Mean	Std	Min	Max	Percentile 25	Percentile 50	Percentile 75	CV
India	16.56%	19.68%	1.79%	52.82%	2.80%	8.00%	21.65%	118.8361145
Thailand	27.35%	11.22%	11.99%	45.12%	18.26%	27.53%	35.40%	41.00624893
Vietnam	21.51%	11.66%	5.44%	37.47%	13.95%	21.98%	29.22%	54.19873755
Pakistan	21.87%	10.72%	10.10%	41.07%	13.57%	18.73%	29.25%	49.0236095
Myanmar	12.41%	12.86%	0.89%	37.50%	1.62%	10.42%	18.50%	103.673265
Japan	0.01%	0.02%	0.00%	0.06%	0.00%	0.01%	0.02%	131.0632683
China	0.10%	0.28%	0.00%	0.79%	0.00%	0.01%	0.01%	269.2907016
Others	0.18%	0.21%	0.00%	0.55%	0.01%	0.13%	0.25%	115.2883346
Total	100.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	1.15433E-06

Source: Author's calculations.

Thailand maintained the highest average share (27.35%), followed by Vietnam (21.51%) and Pakistan (21.87%), while India showed the greatest volatility (standard deviation 19.68%, CV 118.84%). Myanmar also exhibited high variability (CV 103.67%), whereas smaller suppliers (Japan, China, Others) had negligible and stable shares. These patterns highlight Thailand and Vietnam as relatively consistent major suppliers, with India and Myanmar more opportunistic. Another visualization on figure 3 illustrates the year-to-year changes in import shares among major suppliers from 2017 to 2024. Shares fluctuated considerably, with notable spikes for India in 2021 (52.82%) and for Thailand and Vietnam in 2023 (45.12% and 37.47%, respectively). The recent surge in ASEAN suppliers (Thailand and Vietnam) in 2023–2024 visually confirms their increasing role as primary buffers during high-import periods, a stabilizing mechanism now eliminated by the 2026 import ban.

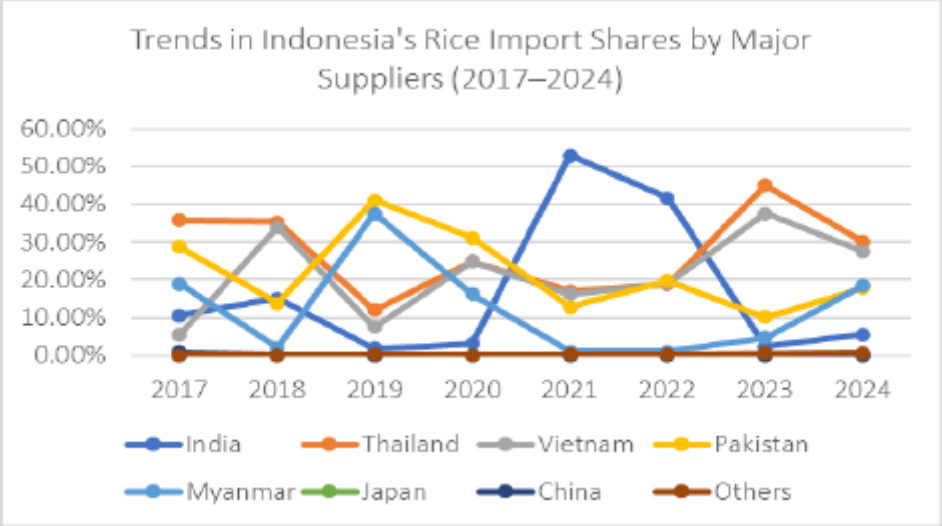


Figure 3 Trends in Indonesia's Rice Import Shares by Major Suppliers (2017–2024)

Source: Processed by Author

The histogram chart below reports the mean import share (blue bars) and the standard deviation of that share (orange bars) for each supplier, based on annual data from 2017–2024. Thailand has the highest mean share (about 27 percent) with moderate volatility, while Vietnam and Pakistan follow with average shares of around 22 percent each. India and Myanmar show smaller average shares (roughly 17 and 12 percent) but relatively large standard deviations, indicating that their exports to Indonesia fluctuate more strongly from year to year than those of Thailand and Vietnam.

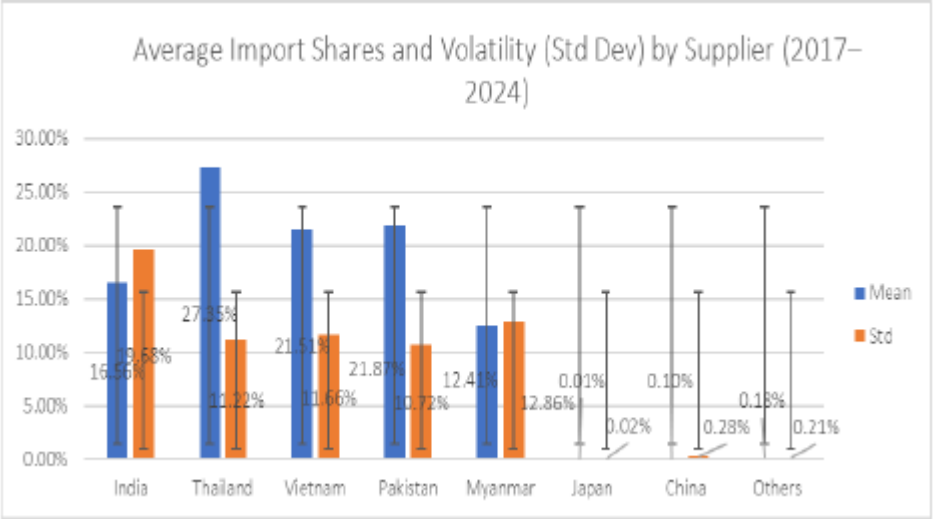


Figure 4 Average Indonesia's Rice Import Shares by Major Suppliers (2017–2024)

Source: Processed by Author

Table 3 Average Import Shares (%), Volumes (Tons), and Volatility in High vs Low-Import Year

Country of Origin	Total	High	Low	Difference	All Years	CV High	CV Low	Avg Ton High	Avg Ton Low
India	1,099,000.0	6.65%	22.89%	-16.23%	90.59%	62.54%	112.33%	218100.8667	88939.4868
Thailand	3,942,112.5	36.01%	20.60%	15.40%	121.16%	28.25%	26.04%	1180584.7	80071.6886
Vietnam	3,449,101.5	32.16%	14.72%	17.44%	123.89%	24.07%	54.59%	1054377.067	57194.0626
Pakistan	1,941,611.8	14.48%	26.63%	-12.15%	102.17%	60.04%	47.15%	474714.8	103493.4822
Myanmar	1,304,040.0	10.31%	14.91%	-4.59%	169.57%	127.18%	114.80%	338134.3333	57927.4
Japan	611.2	0.00%	0.02%	-0.02%	94.79%	93.57%	95.19%	54.13333333	89.7556
China	2,769.7	0.00%	0.13%	-0.13%	242.84%	146.48%	212.88%	84.66666667	503.1402
Others	39,874.4	0.39%	0.10%	0.29%	185.03%	98.85%	94.43%	12650.33333	384.6822
Total	11,779,121.1	100.00%	100.00%	0.00%	109.85%	35.02%	14.74%	3278700.867	388603.6982

Source: Processed by Author.

Table 3 compares average import shares (%) and volumes (tons) in high-import years (total >1 million tons: 2018, 2023, 2024) versus low-import years (≤1 million tons: 2017, 2019–2022). Thailand and Vietnam show substantially higher shares and volumes

in high years (Thailand 36.0% and ~1.18 million tons; Vietnam 32.2% and ~1.05 million tons) compared to low years (20.6% and ~89,000 tons; 14.7% and ~57,000 tons), with differences of +15.4% and +17.4% in shares. In contrast, India and Pakistan have lower shares in high years. These patterns confirm that ASEAN suppliers served as primary buffers during periods of elevated import demand which is a critical role eliminated by the 2026 import ban.

Table 4 presents the Exporter Dependence Ratio (EDR), measuring the share of each country's total world rice exports directed to Indonesia. Myanmar exhibited the highest average dependence (7.94%), followed by Thailand (6.07%) and Vietnam (5.95%). Dependence was particularly pronounced in recent high-import years, with Thailand, Vietnam, Pakistan, and Myanmar reaching 13–30% EDR in 2023–2024. India showed very low dependence (average 0.82%). These ratios indicate that the 2026 ban disproportionately affects Myanmar, Thailand, and Vietnam, implying substantial adjustment pressure in high-import equivalent scenarios.

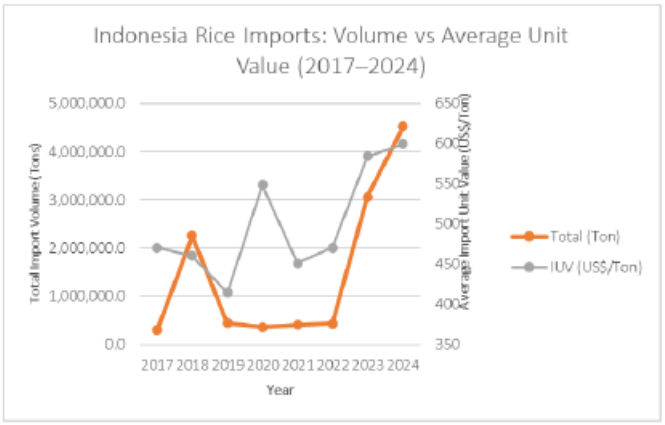
Table 4 Exporter Dependence Ratio (EDR) on Indonesia (Average 2017–2024)

Country of Origin	2017	2018	2019	2020	2021	2022	2023	2024	Total
India	0.27%	3.24%	0.06%	0.05%	0.98%	0.88%	0.48%	1.08%	0.82%
Thailand	0.97%	10.52%	0.93%	1.41%	0.90%	0.92%	13.98%	17.36%	6.07%
Vietnam	0.25%	11.66%	0.54%	1.41%	0.93%	0.99%	12.70%	15.48%	5.95%
Pakistan	2.18%	6.92%	4.78%	2.85%	1.08%	2.25%	4.74%	15.66%	5.33%
Myanmar	2.57%	2.43%	7.16%	2.96%	0.22%	0.18%	8.85%	30.13%	7.94%
Japan	0.12%	0.00%	0.26%	0.00%	0.20%	0.07%	0.07%	0.17%	0.10%
China	0.18%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%

Source: United States Department of Agriculture (USDA) and World Integrated Trade Solution (WITS), and Calculated by Authors.

Figure 5 presents the relationship between annual rice import volume and average import unit value (IUV) from 2017 to 2024. Import volume remained low to moderate (under 500,000 tons) from 2019 to 2022, with IUV fluctuating between approximately 415 and 548 $/ton. A sharp increase occurred in 2023–2024, with volume rising to over 3–4.5 million tons and IUV climbing to 584–600 $/ton. The Pearson correlation coefficient of 0.72 indicates a moderate to strong positive linear relationship, suggesting that Indonesia tended to import larger quantities when average import prices

were elevated. The weaker Spearman rank correlation (0.38) implies that the pattern is not perfectly monotonic across all years. These findings are consistent with imports serving as a partial buffer during tighter or higher-priced market conditions a mechanism now removed by the 2026 import ban, potentially leading to greater price volatility if domestic production shortfalls occur in the future.



Year	Total (Ton)	IUV (US$/Ton)
2017	305,274.8	470.5321238
2018	2,253,824.4	460.1637554
2019	444,508.8	414.5114787
2020	356,286.2	548.4604792
2021	407,741.4	450.7803074
2022	429,207.3	470.7333661
2023	3,062,857.6	584.1028652
2024	4,519,420.6	599.6908763
Correlation	0.723779155	
Rsquared	0.523856265	
Spearman	0.380952381	

Figure 5 Indonesia Rice Import Volume vs Average Import Unit Value (IUV).
Source: Author's Calculation.

Table 5 presents Welch's two-sample t-test results comparing average import unit values (IUV) between high- and low-import years. Overall, IUV was higher in high years (mean ≈548 $/ton) compared to low years (≈471 $/ton), but the difference was not statistically significant (p = 0.216). Country-level tests for major suppliers showed similar non-significant results (p = 0.111–0.352), with Pakistan displaying the closest to marginal significance (p = 0.111). These findings suggest that import volumes tended to occur at somewhat higher prices in high-import periods, consistent with a partial buffering role for imports during tighter market conditions. However, the lack of statistical significance likely due to small sample size in high years (n=3) limits definitive conclusions.

Table 5 Welch's t-test Results: Average Import Unit Value (IUV) in High vs Low-Import Years

Group/Country	High Years Mean IUV ($$ /ton)	Low Years Mean IUV ($$/ton)	p-value	Significant? (p < 0.10)
Overall	547.9858323	471.0035511	0.216	No
Thailand	566.8858506	656.8148106	0.269	No
Vietnam	552.0489784	499.5934901	0.352	No
Pakistan	536.4527066	396.8919116	0.111	No
India	475.3515694	417.6464566	0.202	No

Notes: High years (2018, 2023, 2024); Low years (2017, 2019–2022). Welch's t-test (unequal variances). p-values > 0.10 indicate no statistical significance.
Source: Author's Calculation.

The historical analysis shows that Indonesia relied heavily on imports from Thailand and Vietnam during high-demand years (average ~2.23 million tons combined from these two countries), with recent EDR peaks of 13–30% in 2023–2024 indicating significant exporter dependence on the Indonesian market. The 2026 rice import ban removes this buffer and demand outlet. The removal of imports in 2026 therefore eliminates a historically utilized adjustment mechanism for domestic supply management and a significant destination market for major ASEAN exporters.

Summary of the Study

This study analyzed Indonesia's rice import patterns from 2017 to 2024 to assess structural trade exposure prior to the 2026 import ban. Findings reveal that Thailand and Vietnam were the primary suppliers during high-import years, averaging 36.0% and 32.2% of shares and approximately 1.18 million and 1.05 million tons per year, respectively. The Exporter Dependence Ratio (EDR) showed significant reliance on Indonesia in recent years, with peaks of 13–30% for Thailand, Vietnam, Pakistan, and Myanmar. A moderate positive correlation (Pearson r = 0.72) between import volume and average import unit value (IUV) suggests imports tended to occur during tighter market conditions. Although Welch's t-tests found no statistically significant difference in IUV between high and low years, the directional pattern supports the interpretation of imports as a partial buffer. Overall, the findings highlight the structural importance of Indonesia within regional rice trade and the potential adjustment challenges for exporters following the 2026 ban.

Discussions

The findings align with existing literature on rice trade concentration and price transmission in ASEAN. Widarjono (2018) and Antriyandarti et al. (2024) showed that imports from Thailand and Vietnam are relatively price-inelastic and serve as a complementary stabilization tool during domestic shortfalls, consistent with the moderate volume-IUV correlation (r = 0.72) and directional (though non-significant) higher IUV in high years observed here. The high EDR in recent years (13–30% for Thailand, Vietnam, Pakistan, and Myanmar) supports Greenville (2018), who highlighted that policy shocks in large importers create spillover effects on concentrated exporters. The elimination of imports removes a historically observed adjustment channel during high-demand years. Prior literature indicates that import restrictions can increase domestic price gaps and volatility (Patunru & Ilman, 2019; Rosner & McCulloch, 2008). Given the concentration of export supply in ASEAN (Greenville, 2018), the 2026 ban may therefore reshape regional trade flows and heighten adjustment pressures for exporters with high dependence on the Indonesian market. The empirical results indicate that the ban disproportionately affects ASEAN exporters, especially Thailand and Vietnam, as well as Myanmar, while large and globally diversified exporters such as India face comparatively limited exposure.

Recommendations

This study suggests several areas for future research and policy consideration. First, more granular (monthly or sub-national) data could improve precision in modeling price volatility and regional distribution effects under the ban. Second, econometric approaches such as ARIMA or vector autoregression (VAR) using longer time series could refine volume and price projections beyond qualitative scenarios. Third, future work should examine the role of ASEAN emergency reserves (APTERR) in mitigating spillover effects on high-EDR countries (Myanmar, Thailand, Vietnam). Policy recommendations include: (1) strengthening domestic production resilience (e.g., irrigation, pest control) to reduce shortfall risks; (2) improving distribution efficiency to prevent retail price pressure despite surplus; and (3) enhancing regional cooperation mechanisms to stabilize trade

flows for affected exporters. Monitoring post-2026 trade and price developments will be essential to evaluate the actual adjustment effects of the import ban.

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Effects of A Multisensory-Based Mindfulness Program on Stress and Anxiety Levels in People Living with HIV Who Use Methamphetamine

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Abstract

HIV infection is associated with methamphetamine use, particularly among men who have sex with men (MSM), and may contribute to neuropsychiatric consequences such as heightened stress and anxiety, which can adversely affect daily functioning and engagement in meaningful daily activities. Although various interventions are available to address stress and anxiety, many present practical and clinical limitations in their application. This case study investigated the effects of a multisensory-based mindfulness program on stress and anxiety in an individual with methamphetamine use and co-existing HIV infection.

The program was implemented through three principal occupational therapy processes: (1) evaluation, (2) intervention, and (3) outcome assessment. Occupational history and occupational performance were evaluated using the Occupational History Interview (OHI), Suanprung Stress Test-20 (SPST-20), Generalized Anxiety Disorder Scale-7 (GAD-7), and Canadian Occupational Performance Measure (COPM), administered before and after the intervention. The findings indicated that participation in the multisensory-based mindfulness program was associated with reductions in both stress and anxiety. Specifically, stress scores decreased from 50 (high) to 33 (moderate), while anxiety scores declined from 7 (mild) to 2 (minimal). In addition, improvement was observed in the health management domain, reflected by increased occupational performance (4.5-point increase) and satisfaction (5.5-point increase).

However, these results are preliminary and based on a single participant; therefore, studies with larger samples and longer-term follow-up are needed to confirm the program's effectiveness and assess the sustainability of its outcomes.

Keywords: Multisensory mindfulness, Methamphetamine use, HIV, Stress and anxiety, Occupational therapy intervention

Introduction

Methamphetamine, commonly referred to as crystal methamphetamine, is a highly addictive psychostimulant that acts on the central nervous system (National Institute on Drug Abuse, 2013). Methamphetamine use is frequently associated with high-risk sexual behaviors, particularly among men who have sex with men (MSM), a population in which the prevalence of use is often reported to be elevated. A study in the United States, substance use was reported in up to 73% of participants, with methamphetamine the most commonly used substance (50 %) (Fulcher et al., 2021). In Southeast Asia, methamphetamine use has increased substantially, with some reports indicating a rise from approximately 30% to 50% (Feelemyer et al., 2020). Similarly, in Thailand, methamphetamine use has been reported at 44.4% and appears to be particularly prevalent among MSM living with HIV, potentially reflecting increased recreational use in recent years (Boonruang et al., 2025; Muccini et al., 2024). These findings highlight the significant neuropsychiatric effects observed in methamphetamine users living with HIV, extending beyond addiction itself and contributing to stress and anxiety (Glasner-Edwards et al., 2010). This may be related to difficulties in managing addictive behaviors and coexisting health problems that interfere with daily functioning and everyday activities.

Stress and anxiety are closely linked among methamphetamine users living with HIV. Stress can act as a trigger for substance use, as individuals may use substances to cope with distress and escape life's problems, with the substance providing a temporary sense of relief (Nevendorff & Praptoraharjo, 2015). Among MSM, stress related to social stigma, family rejection, and shame associated with sexual identity can be major factors driving substance use as a coping strategy. In addition, some people living with HIV who use substances to manage illness-related stress and cope with feelings of social isolation (Cebo, 2017; Gómez et al., 2024). In terms of anxiety, crystal methamphetamine use is strongly associated with anxiety-related symptoms. One study reported that 76% of regular users experienced severe anxiety, and 33% experienced panic attacks after initiating use. Continued use may also lead to severe paranoid and anxiety-related symptoms that can progress to psychosis, in which users may feel watched or threatened. In addition, during withdrawal, users often experience "Crash" marked by

intense anxiety (Salo et al., 2011). These emotional disturbances may be linked to dysregulation of the brain's hypothalamic pituitary adrenal (HPA) axis, which plays a central role in the stress and anxiety response.

The HPA axis is a core neuroendocrine system that regulates the body's response to stress and anxiety. Activation begins with the release of corticotropin-releasing hormone (CRH) from the hypothalamus, which stimulates the pituitary gland to secrete adrenocorticotropic hormone (ACTH). ACTH then triggers the adrenal cortex to release glucocorticoids (cortisol in humans) into the bloodstream (Stephens & Wand, 2012; Zuloaga et al., 2015). Under normal conditions, this system is regulated by a negative feedback mechanism that suppresses further hormone release once the stressor has resolved (Herman et al., 2016). In methamphetamine users, the HPA axis is often chronically overactivated, leading to maladaptive neurobiological changes involving the amygdala and dopaminergic signaling. Long-term methamphetamine use is associated with dysregulated dopamine activity, which can impair neuronal function in the prefrontal cortex (PFC)—a region essential for executive control, decision-making, and cognitive regulation. This dysfunction may contribute to reduced analytical thinking and compulsive behaviors. At the same time, activity in the amygdala and striatal circuits, which are involved in emotional reactivity and habitual behavior, may become heightened (Arnsten, 2009; Zuloaga et al., 2015). An imbalance between the brain's prefrontal and limbic systems can lead to impulsive, emotion-driven responses and impaired regulation of stress and anxiety.

Widely used approaches for managing stress and anxiety includes: (1) Cognitive behavioral therapy (CBT), a first-line treatment that focuses on identifying and restructuring maladaptive thoughts, modifying behaviors, and using evidence-based techniques (e.g., exposure-based and skills-based strategies) to reduce fear and distress (Curtiss, Levine, Ander, & Baker, 2021). However, CBT is a cognitively demanding, thought-based therapy that emphasizes cognitive restructuring and behavior change. It requires higher-order (metacognitive) skills and sustained mental effort, which may be challenging for some patients compared with interventions that make fewer demands on cognitive processing (Fresco & Mennin, 2019). Therefore, this may be a limitation for patients with coexisting impairments in memory and frontal lobe function. (2) Psychosocial

interventions are often used in specific clinical and community settings and typically integrate multiple strategies, including stress management, resilience training, problem-solving therapy, and supportive counseling (Ozturk, San, & Yildiz, 2025). This type of intervention often faces a substantial gap between theory and clinical practice, which can limit its implementation in real-world care. In addition, some approaches may be overly prescriptive and difficult to apply consistently in routine practice (Institute of Medicine, 2015). And (3) Mindfulness-based training programs focus on awareness. That is intentionally attending to present-moment experiences in a nonjudgmental way, to strengthen emotional regulation, reduce stress and anxiety (Alvarado-García, Soto-Vásquez, Infantes Gomez, Guzman Rodriguez, & Castro-Paniagua, 2025). Nevertheless, some cases of intensive mindfulness practice may precipitate acute psychiatric symptoms (e.g., psychosis) in vulnerable individuals. In addition, approximately 6 % to 14 % of participants in mindfulness programs have been reported to experience persistent adverse effects such as hyperarousal, dissociation, or increased anxiety, which may be associated with difficulties in emotional regulation (Britton, Lindahl, Cooper, Canby, & Palitsky, 2021; Joshi, Manandhar, & Sharma, 2021). Based on the limitations of existing approaches, particularly the heavy reliance on higher-order cognitive skills and the need to promote realistic, present-moment awareness in a clinically engaging environment, multisensory stimulation combined with mindfulness practice was applied as a guiding approach for managing stress and anxiety in methamphetamine users living with HIV.

Multisensory stimulation involves the structured and appropriate delivery of two or more basic sensory stimuli simultaneously, such as touch, smell, sound, visual input, and movement. Its goal is not primarily to train cognitive skills, but rather to promote active engagement with ongoing sensory experiences (Silva et al., 2018; Vorayot & Thamrongsottisakul, 2022). Multisensory stimulation promotes active self-engagement in clients, which may enhance self-awareness of their thoughts, emotions, and actions (Fowler, 2007). Similarly, mindfulness practice emphasizes awareness of present-moment experience and is associated with reduced negative affect (e.g., stress and anxiety) and increased positive affect. Mindfulness and breathing practices may also help regulate sympathetic and parasympathetic balances, which can contribute to lower cortisol levels (Mutumba et al., 2021; Dsouza, Aghili, Nasiri, & Asghari, 2021).

Therefore, multisensory-based mindfulness focuses on helping participants explore diverse sensory experiences across multiple sensory systems while engaging in mindfulness practice that cultivates full, nonjudgmental awareness of present-moment experience and free from automatic judgments shaped by prior beliefs or past experiences. In this approach, sensory stimulation is not used merely for physical activation, but to foster deep, moment-to-moment awareness of each sensory experience (Garland et al. 2015; Whear et al., 2014). Therefore, this case study aims to examine the effects of a multisensory-based mindfulness program on stress, anxiety, and occupational performance in a methamphetamine user.

Process conceptual framework

This case study applied the occupational therapy process in accordance with the Occupational Therapy Practice Framework: Domain and Process (4thed.) (American Occupational Therapy Association, 2020). This framework guided the clinical reasoning process for the design, implementation, and evaluation of the multisensory-based mindfulness intervention in this study, which consists of the following three process components:

1. Evaluation: The evaluation process begins with consultation and screening conducted by the multidisciplinary team within occupational therapy services. It is followed by interviews regarding daily life experiences, including assessment of occupational performance, contextual factors, and the client's skills, capacities, and patterns of daily living. Finally, the information gathered is synthesized to determine occupational outcomes and the impact on everyday activities.

2. Intervention: During the intervention phase, the multisensory-based mindfulness program was
implemented through structured sessions designed to engage multiple sensory modalities while promoting present-moment awareness. This phase also involved ongoing reassessment and review of the participant's response to treatment, and modification of the plan as needed.

3. Outcomes: This process involves using outcome measures to evaluate progress toward desired goals, as reflected by changes in stress, anxiety, and

occupational performance scores. It also included discharge to planning of daily life performance following the completion of rehabilitation.

Instruments

The instruments used in this study were divided into two categories: data collection instruments and activity implementation instruments.

1. **Data collection instruments**

1.1 The Occupational History Interview (OHI) was adapted form Saolorm et al. (2007) and consists of five main sections: educational history, work history, family history, leisure history, and time-use habits.

1.2 The Suanprung Stress Test-20 (SPST-20) was developed by Mahatnirankul et al. (1997). It consists of 20 items; each rated on a 5-level scale.

1.3 The Generalized Anxiety Disorder Scale (GAD-7) was translated into Thai by the Faculty of Medicine, Ramathibodi Hospital, Mahidol University (2015), based on the original instrument developed by Spitzer et al. (2006). It consists of 7 items; each rated on a 4-level scale.

1.4 The Self-Assessment of Occupational Performance is an adapted version of the Canadian Occupational Performance Measure (COPM). The Thai version was translated by Khemthong (2023).

2. **Activity implementation instruments**

The multisensory-based mindfulness program was delivered over seven consecutive days, from August 29 to September 4, 2024. It consisted of seven sessions, each lasting approximately 60 minutes and organized into the following two activity sets:

2.1 Activity Set 1 consisted of three psychoeducational components: mindful sensory awareness, the brain and addiction cycles, and the effects of substances on sensory processing. It also incorporated multisensory stimulation–based mindfulness activities, including environmental modification through the use of musical instruments and Thai spa–scented essential oils, as well as yoga and loving-kindness practices.

2.2 Activity Set 2 consists of two psychoeducational components: stress on sensory processing, and anxiety on sensory processing. In addition, it included multisensory stimulation–based mindfulness activities, such as environmental

modification using musical instruments and Thai spa–scented essential oils, together with yoga and loving-kindness practices., mindfulness using sand trays, and relaxation techniques.

Case study information

1. General information: A 22-year-old Thai male undergraduate student was diagnosed with methamphetamine dependence (F15.2) and had comorbid conditions, including HIV infection (B24), syphilis (A53.9), and allergic rhinitis (J30.4).

2. Chief Complaint: The participant presented to the hospital 6 days after crystal methamphe- tamine use.

3. Medical history: The participant was referred for methamphetamine dependence treatment, which the participant had not previously received treatment. The participant expressed a desire to stop using drugs and informed his mother, who then brought him for care. At the time of initial admission, he was able to respond to questions clearly.

4. History of substance use: The participant began using crystal methamphetamine at age 21, injecting it intravenously once weekly at a dose of 0.2 cc for approximately 8 months. Approximately 3 months prior to admission, he developed auditory hallucinations (hearing voices), paranoia, tremors, restlessness, and intense cravings when not using the drug. The participant decided to take a leave of absence from school in an effort to quit and was able to abstain for about 1 month before relapsing, reportedly due to peer influence and exposure to drug-related advertising. His last reported dose of crystal methamphetamine was 0.2 cc.

5. Psychosocial context: The participant was a man who has sex with men (MSM) who reported methamphetamine use primarily in association with sexual activity. The participant was unable to discontinue use until neurological symptoms emerged. Furthermore, he experienced considerable stress, and the diagnosis of HIV and other sexually transmitted infections further heightened his anxiety about the future.

Ethical Consideration

This case study was conducted as part of the occupational therapy service. Before the study commenced, the participant provided written informed consent and agreed to the disclosure of relevant information for research purposes, without infringement of rights or risk of harm. The researcher explained the study objectives, the occupational therapy services, the data collection procedures, and the expected benefits. Participation was entirely voluntary, and the participant was informed of the right to withdraw from the study at any time without providing a reason and without any adverse effects on safety or care. All information obtained from this case study was treated confidentially and is presented only in an anonymized, general form.

Application of the conceptual process framework in a case study

1. Evaluation process

The therapist reviewed the participant's medical history, introduced themselves, and invited to participate in the case study. The purpose of the study was explained, and the participant was interviewed regarding daily living activities using the OHI. Assessments were then conducted using instruments including the SPST-20, GAD-7, and COPM. The collected data were interpreted to determine the impact on occupational performance and daily activities, and to inform analysis of rehabilitation needs and intervention planning. The assessment results were as follows:

1.1 Occupational history: The participant is a third-year undergraduate student who has taken a two semester leave from his studies. He remains interested in completing his degree, and his parents continue to support his education. He previously worked part-time at an ice cream shop and also earned additional income as a VJ (live streamer) after school. Currently, he helps his mother sell beverages, such as tea and coffee at home. His interests and passions include design. His family consists of four members: his father, mother, younger sister, and himself. His preferred leisure activities include listening to music, drawing, and watching movies. His time-use patterns are presented in Table 1.

Based on the time-use patterns, daily activities can be categorized using the concept of occupational balance, which Backman (2004) described in terms of major

activity domains (e.g., self-care, productivity, and leisure). As shown in Chart 1, while at home, leisure activities accounted for the largest proportion of time (37.5%), followed by self-care activities (33.33%) and productivity activities (29.17%). In contrast, while living at dormitory, self-care activities accounted for the largest proportion (50%), followed by productivity activities (33.33%) and leisure activities (16.67%).

1.2 Occupational performance: A pre-program SPST-20 assessment showed a stress score of 50, indicating a high level of stress. A pre-program GAD-7 assessment yielded an anxiety score of 7, indicating a moderate level of anxiety. The COPM assessment indicated that the client placed the highest importance on health management in relation to irritability associated with stress and anxiety (importance score = 9). Prior to the program, the participant's self-rated performance in managing stress and anxiety was 5 scores, and satisfaction with that performance was also rated as 5 scores.

Table 1 shows details of the time-use pattern

Location	Activities domain	Activities	Time (hours)
At home	Self-care	- Wake up and grooming	1
		- Breakfast	1
		- Lunch	1
		- Dinner	1
		- Sleep	4
		Total	**8**
	Productivity	- Assisted mother with work	1
		- Wash clothes	1
		- Assisted with managing the shop	4
		- Housework	1
		Total	**7**
	Leisure	- Listening to the news and watching movies	1
		- Playing computer games	3
		- watching movies with family members	2
		- Playing on a mobile phone	3
		Total	**9**
At dormitory	Self-care	- Sleep	9
		- Wake up and grooming	1
		- Lunch	1
		- Dinner	1
		Total	**12**
	Productivity	- Studying	8
		Total	**8**
	Leisure	- Methamphetamine using	4
		Total	**4**

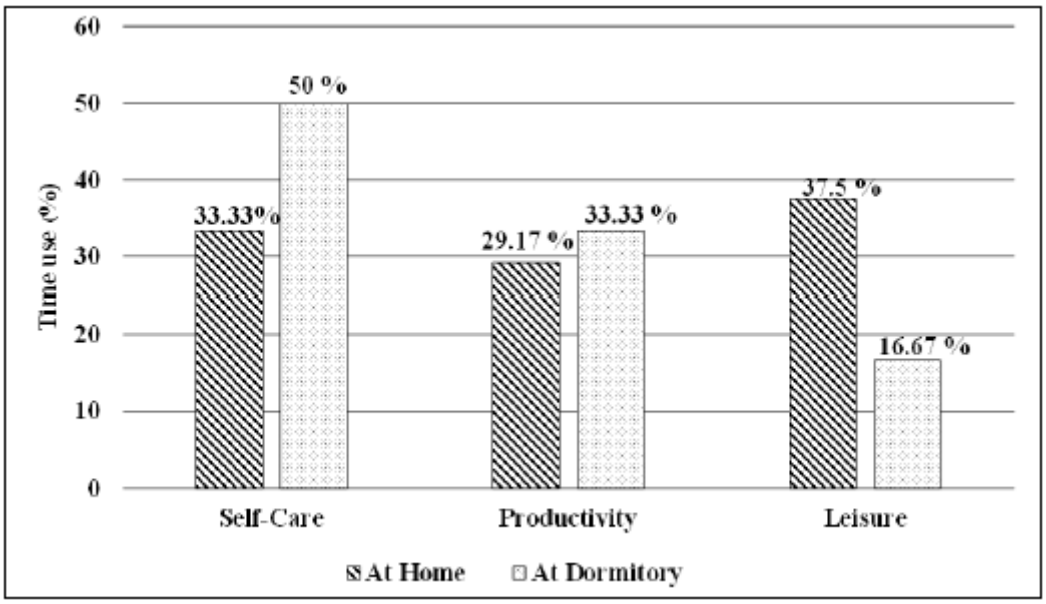


Chart 1 Compare time use across each domain of daily living activitiesbetween at home and at dormitory.

2. Intervention process

This process involves establishing short-term and long-term goals (Table 2) and the program was structured as seven 60-minute multisensory stimulation–based mindfulness sessions incorporating visual, auditory, olfactory, movement-based (vestibular and proprioceptive), and interoceptive modalities. Throughout each session, participants were encouraged to maintain present-moment awareness, focus on their ongoing activities, and respond to all perceptions with a nonjudgmental attitude, consistent with the core principles of mindfulness practice, as outlined in Table 3.

Table 2 shows details of the goals

Goals	Details
1. Short-term	- To reduce SPST-20 scores by at least 41 points after 7 sessions. - To reduce GAD-7 scores by at least 4 points after 7 sessions.
2. Long-term	- To improve readiness for role resumption in education (e.g., increased engagement in structured daily routines)

Table 3 shows the mindfulness-based multisensory stimulation activities plan

Sessions	Activities	Time (mins)
1	- Greeting, introduce the study and written informed consent for case study participation.	20
	- Assess occupational history using the OHI and evaluate occupational performance and related outcomes using the SPST-20, GAD-7, and COPM.	35
	- Summary of session and next appointment.	5
2	- Greeting and an introduction to today's activities.	5
	- Psychoeducation was provided on "Sensory Awareness".	10
	- Activities set 1 practice.	35
	- Summary of session and next appointment.	10
3	- Greeting and an introduction to today's activities.	5
	- Psychoeducation was provided on "Brain & Addiction Circuit".	10
	- Activities set 1 practice.	35
	- Summary of Activities and Next Appointment	10
4	- Greeting and an introduction to today's activities.	5
	- Psychoeducation was provided on "Substances Use & Sensory Processing"	10
	- Activities set 1 practice.	35
	- Summary of session and Next Appointment.	10
5	- Greeting and an introduction to today's activities.	5
	- Psychoeducation was provided on "Stress & Sensory Processing"	10
	- Activities Set 2 practice.	35
	- Summary of session and Next Appointment.	10
6	- Greeting and an introduction to today's activities.	5
	- Psychoeducation was provided on "Anxiety & Sensory Processing"	10
	- Activities Set 2 practice.	35
	- Summary of session and next appointment.	10
7	- Greeting and an introduction to today's activities.	5
	- Activities Set 2 practice.	35
	- Evaluate occupational performance and related outcomes using the SPST-20, GAD-7, and COPM.	15
	- Summary and conclusion of the program.	5

3. Outcome process

This involves comparing the data to identify changes in rehabilitation progress and summarizing outcomes in line with the objectives, as follows:

3.1 Stress scores

This section compares stress scores (SPST-20) before and after the program. Details are presented in Table 4.

Table 4 shows a comparison of stress scores before and after participation in the program

Evaluations	Stress scores	Interpretations
Before	50	High
After	33	Moderate

According to Table 4, before participating in the program, a participant had a stress score of 50, indicating a high level of stress. After completing the program, his stress score decreased to 33, indicating a moderate level of stress. Overall, stress levels decreased by 17 points following the program.

3.2 Anxiety scores

This section compares anxiety scores (GAD-7) before and after the program. Details are presented in Table 5.

Table 5 shows a comparison of anxiety scores before and after participation in the program

Evaluations	Anxiety scores	Interpretations
Before	7	Mild
After	2	Minimal

Table 5 shows that, before participating in the program, the participant's anxiety score was 7, indicating a mild level of anxiety. After completing the program, the score decreased to 2, reflecting a minimal level of anxiety. Overall, this represented a 5-point reduction in anxiety by the end of the program.

3.3 The Self-Assessment of Occupational Performance

This section compares occupational performance, based on performance and satisfaction scores from the Canadian Occupational Performance Measure (COPM), before and after participation in the program. Details are presented in Table 6.

Table 6 shows a comparison of performance and satisfaction scores before and after participation in the program

Area	Problems	Performance scores		Satisfaction scores	
		Before	After	Before	After
Health management	- Gets irritated easily when stressed.	5	10	4	10
	- Gets irritated easily when anxious.	5	9	4	9
	Average scores	5	9.5	4	9.5
				Changes in performance scores = 4.5 points	
				Changes in Satisfaction scores = 5.5 points	

Table 6 shows that after completing the program, participants' performance and satisfaction scores for managing stress and anxiety improved. Overall, the participant demonstrated improvements in perceived performance and satisfaction, with performance scores increasing by 4.5 points and satisfaction scores increasing by 5.5 points. The observed improvements exceed the clinically meaningful threshold for COPM.

Case study discussion

1. Occupational Pattern

The participant entered the program on August 26, 2024. The initial assessment indicated that, while staying in the dormitory, the participant used his time inappropriately and engaged in maladaptive leisure activities. Specifically, methamphetamine use during a high-risk period from 8.00 p.m. to midnight. This suggests that the participant's daily living activities and time-use patterns, particularly during unstructured free time that contributed to engagement in inappropriate leisure activities during this critical period (i.e., drug use). This finding is consistent with Farhadian et al. (2024), who reported that unstructured time is associated with increased relapse risk, highlighting the importance of structured activity engagement. Therefore, facilitating engagement in meaningful leisure occupations is a key strategy to support relapse prevention. Accordingly, the participant should be supported to identify meaningful leisure activities, then encouraged to participate during free time. Especially, during the identified high-risk period to promote healthier and more adaptive patterns of daily activity.

2. Effects of multisensory stimulation program

Firstly, the multisensory-based mindfulness program creates varied sensory experiences through structured environments (multisensory environments: MSEs), similar to a Snoezelen room. A systematic review and meta-analysis by Helbliing et al. (2024) reported that multisensory environment therapy can support rehabilitation outcomes related to anxiety, depression, cognitive impairment, and associated behaviors such as restlessness. This aligns with Halliwell et al. (2024), who found that multisensory environment therapy positively reduced stress and anxiety and increased relaxation among community participants, which may explain the observed reductions in stress and anxiety in this case. However, Silva et al. (2018) noted that these effects may not be sustained over the long term. Therefore, to enhance maintenance of benefits, it may be helpful to provide an ongoing space in which participants can choose and engage with the sensory systems that best meet their needs. Such individualized engagement may support effective sensory processing and integration, which in turn can strengthen self-regulation skills and promote greater awareness and understanding of one's emotions.

Secondly, incorporating contemporary mindfulness principles into the activities, particularly through yoga-based mindfulness, Satipatthana mindfulness, and sand-tray mindfulness, engages multiple sensory modalities. Yoga-based mindfulness can promote deep muscular relaxation. From the perspective of reciprocal inhibition, Yin yoga mindfulness may function similarly to a relaxation-based systematic desensitization approach: relaxation responses are physiologically incompatible with heightened fear and anxiety, and cultivating relaxation may therefore help reduce anxiety-related arousal (Jaknissai, 2017). It is therefore possible that reductions in stress and anxiety may stem from muscle relaxation and reduced exposure to stimulating events, at the same time, with mindfulness practice that supports observing emotions as they arise in the present moment. This awareness may represent an initial step in self-regulation, helping individuals manage their thoughts, feelings, and actions. Similarly, the mindfulness model, this practice reflects a process-like interaction among intention, attention, and attitude (Shapiro, 2006). Therefore, while engaging in physical movement, individuals direct their attention to the present moment by attending to their actions and sustaining continuous awareness of the breath. This process may be interpreted as cultivating

insight and heightened awareness and, when practiced repeatedly, may parallel the repeated working-through process in mindfulness-based dynamic psychotherapy. (Disayavanish & Disayavanish, 2014). It is therefore possible that the participant may develop greater understanding of emotions and experience relief from stress and anxiety. In mindfulness-based sand-tray training, a sensory experience is created through intentional, creative activity performed with mindful awareness of the breath and body movement within a multisensory environment (MSE). This allows participants to use imagination and symbolic expression to support emotional coping and psychological well-being. This is consistent with the study by Saritnirun & Kunthajun (2015) on sand-tray therapy based on the Satir model, which emphasizes beliefs about people, adaptation, and change, with the overall goal of growth (metagoal) alongside individualized goals (specific goal). Through arranging objects in the sand tray, the participant may gain insight into their true selves, needs, and desires, resolve internal conflicts, and process both positive and negative feelings. Similarly, in activities such as arranging marbles on a sand tray, thoughts and emotions may naturally arise. When participants engage in the task with mindful attention without resistance, force, or judgment, this may support a smoother, "flow-like" emotional processing through symbolic arrangement, which may contribute to reduced stress and anxiety.

Thirdly, an additional finding relates to psychoeducation in occupational therapy. Psychoeducation involves providing the participant with information that builds a foundational understanding of their condition, appropriate treatment approaches, and available support services. In this program, occupational therapy psychoeducation used an executive approach to reshape participant's understanding by incorporating current, socially appropriate information delivered in a structured, step-by-step manner (Padilla, 2002). Consistent with the SLA (Sharing–Learning–Application) framework for mental health education, which emphasizes sharing experiences, learning new knowledge, and applying it in real-life situations. As a result, a participant of SLA-based mental health education may develop greater understanding of mental health conditions, experience reduced stress, improve quality of life, enhance self-confidence, and become better able to recognize and manage symptoms and warning signs (Limpitikiat, Sasok, and Phawo 2023). Therefore, providing a participant with information about brain mechanisms

related to emotion and the effects of substance use on the brain may enhance awareness and engagement in therapeutic activities, contributing to reduced stress and anxiety levels and improving COPM from pre- and post-programs.

However, based on the summary discussions conducted after each activity and considering motivation for behavior change, this increased awareness may reflect progression in the participant's readiness for change related to substance-use cessation. The participant appeared to be in the contemplation stage and trending toward the determination/preparation stage. Therefore, interventions should emphasize the consequences and benefits of change, address perceived barriers and potential negative aspects of change, and provide ongoing support and skills training to encourage and reinforce appropriate, substance-free behaviors.

Conclusion

This case study involved a participant who completed a multisensory stimulation–based mindfulness program consisting of seven 60-minute sessions conducted from August 29, 2024, to September 4, 2024. Following the intervention, the results indicated a reduction in stress from a high to a moderate level and a decrease in anxiety from a moderate to a low level. In addition, improvements were observed in performance and satisfaction related to daily living activities. These findings should be interpreted as preliminary, as they are derived from a single-case study and are therefore subject to inherent limitations. Further research is needed to confirm and extend these results.

Limitations

1. The limited duration and frequency of participation meant the activities could not be planned and delivered as intensively as intended.
2. The limited space in the activity room made it difficult to fully implement the intended walking pace and the planned duration for observing feelings.
3. The participant received various treatment programs from a multidisciplinary team, which may lead to fatigue during activities.
4. The single-case design and absence of a control condition limit the ability to generalize findings and establish causal relationships.

Future research

1. Follow up on the effects of a multisensory-based mindfulness program on stress and anxiety levels after discharge, including continued practice at home.

2. Develop a standardized program model and evaluate it further using multiple participant groups to compare outcomes and confirm the findings.

3. Future studies should employ rigorous research designs commonly accepted in medical and health science research, such as randomized controlled trials (RCTs).

4. Valid and reliable instruments should be developed or selected to assess stress, anger, and performance in daily activities, with careful consideration of their suitability for the target population.

5. Longitudinal research should be conducted to examine the program's effects over time and to complement findings from cross-sectional clinical studies.

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Port Competition and Hinterland Reconfiguration in the GMS: A Tripolar Balance

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Abstract

This paper studies how integration shocks reshape cross-border spatial equilibria in the Greater Mekong Subregion (GMS). Specifically, we examine whether new gateway capacity generates winner-takes-all dominance or stabilizes a polycentric (tripolar) configuration. Exploiting the 2015 deep-water expansion of Sihanoukville Port (SHV), we quantify hinterland responses across 47 inland provinces in Cambodia, Lao PDR, and Northeast Thailand over 2012–2021. To overcome cross-country data scarcity, we combine harmonized VIIRS night-time lights with a multi-period event-study difference-in-differences design, defining treatment intensity by pre-event road distance to SHV. Robustness analyses explicitly address local port-city confounding (donut restrictions) and spatial dependence. Empirically, we document persistent post-2015 growth concentrated along intermediate-distance corridor belts, confirming network-mediated spillovers rather than localized port-city shocks. This emergence of an additional growth pole refutes zero-sum displacement, motivating a governance approach that leverages gateway expansions to institutionalize regional balance and resilience in the GMS.

Keywords: Port competition; hinterland reconfiguration; night-time lights; event-study DID; Greater Mekong Subregion

Background and Statement of the problem

Regional integration in the Greater Mekong Subregion (GMS) is increasingly driven by logistics corridors rather than national borders. Transport connectivity—roads, border checkpoints, and port access—has become a central mechanism that reallocates economic activity and alters the regional geography of growth (Fujita et al., 1999; Redding and Turner,

2015). A defining feature of the southern GMS is its contested hinterland: interior provinces across Cambodia, Lao PDR, and Northeast Thailand are simultaneously connected to multiple international deep-water gateways, including Laem Chabang (Thailand), Ho Chi Minh City (Vietnam), and Sihanoukville (Cambodia). As these gateways expand capacity, a fundamental spatial-economic question arises: does integration produce a dominant hub that pulls activity toward one gateway (a winner-takes-all outcome), or can multiple gateways coexist in a stable, polycentric system where benefits diffuse across inland corridors (Krugman, 1991; Baldwin, 2016)?

While the theoretical tension between agglomeration (concentration) and dispersion (polycentricity) is well-established in New Economic Geography and transport economics (Krugman, 1991; Donaldson, 2018), empirical evidence on how port investments reshape inland economic distribution remains fragmented. The port competition literature frequently focuses on aggregate cargo flows and gateway selection (Ducruet and Notteboom, 2012), whereas recent corridor economics emphasizes localized "growth belts" driven by firm reallocation (Banerjee et al., 2020). However, evaluating these dynamics in a contested, cross-border region requires moving beyond national-level trade statistics to observe subnational spatial adjustments.

This objective faces three persistent empirical challenges, which are particularly binding in the GMS. First, standard regional accounts are often incomplete or lack cross-border comparability, limiting the tracking of consistent subnational outcomes. Second, infrastructure expansion is frequently endogenous; ports and corridors are upgraded where growth is already anticipated, confounding causal interpretation (Redding and Turner, 2015). Third, spatial dependence is intrinsic to transport networks, as gateway shocks propagate across neighboring provinces, complicating inference if spatial correlation is ignored (Conley, 1999). Consequently, while the regional policy debate on corridor development is fast-moving, rigorous subnational, cross-border evidence regarding the spatial effects of gateway capacity expansions remains notably scarce.

Statement of the Problem

The 2015 deep-water expansion of Sihanoukville Port (SHV) provides a discrete shock to evaluate how gateway capacity affects the spatial distribution of economic activity across a contested cross-border hinterland. This triggers two competing spatial adjustment hypotheses: does improved market access drive agglomeration toward a

single dominant hub (a winner-takes-all hierarchy), or does it operate through network spillovers to foster a polycentric, tripolar balance across the southern GMS?

The practical stakes are high: a winner-takes-all equilibrium amplifies spatial inequality and vulnerability to localized disruptions, whereas a polycentric system strengthens regional resilience. Yet, current policy debates rely heavily on aggregate port-level throughput or national trade statistics. These macro-metrics obscure whether economic growth is genuinely diffusing inland or merely reflecting localized port-city dynamics, leaving a critical gap in our understanding of corridor-led integration.

Motivated by these gaps, this paper formulates the research problem as follows:

Motivated by this gap, this paper formulates the following research questions:

Causal impact: Did the 2015 SHV expansion increase economic activity in more exposed inland provinces relative to less exposed ones?

Spatial mechanism: Are post-expansion gains concentrated near the port (indicating local construction dynamics) or distributed along intermediate-distance corridor belts (indicating network spillovers)?

Equilibrium & Governance: Do these spatial responses support a winner-takes-all hierarchy or the emergence of an additional growth pole? Consequently, how can corridor governance be structured to sustain polycentric growth rather than excessive concentration?

By applying a robust identification strategy to harmonized subnational data, this study reframes port expansion from a purely competitive throughput narrative to a regional governance challenge of stabilizing cross-border balance.

Objective

The purpose of this research is to identify and interpret how a major gateway-capacity shock reshapes the cross-border spatial distribution of economic activity in the Greater Mekong Subregion (GMS), and to assess whether the resulting adjustment is consistent with a winner-takes-all hierarchy or a stable, polycentric (tripolar) regional equilibrium.

Specifically, this study aims to:

Estimate the causal impact of the 2015 Sihanoukville Port (SHV) deep-water expansion on hinterland economic activity across inland provinces in Cambodia, Lao PDR, and Northeast Thailand, using harmonized VIIRS night-time lights as a comparable proxy outcome.

Characterize the spatial gradient and corridor structure of the effects, distinguishing corridor-mediated spillovers (intermediate-distance belts and route-aligned patterns) from purely local port-city dynamics or construction-related noise near the port.

Test the robustness and credibility of inference by directly addressing key empirical threats differential pre-trends, alternative exposure definitions, local confounding around the port (donut restrictions), and spatial dependence so that results are not driven by coincident macroeconomic conditions or simple light–economy correlations.

Derive implications for regional-balance governance in the GMS, evaluating whether gateway expansions can be understood as instruments that institutionalize polycentric development and resilience, rather than mechanisms that intensify zero-sum displacement and concentration.

Expected benefits

1. Strategic Guidance for GMS Regional Development Policy

This study provides subnational, cross-border evidence that equips GMS policymakers to evaluate whether corridor-led integration fosters broad-based growth or exacerbates spatial inequality. By distinguishing a winner-takes-all dynamic from the formation of a stable polycentric (tripolar) system, the findings directly inform governance strategies aimed at sustaining regional balance across Cambodia, Lao PDR, and Thailand.

2. Actionable Investments for Corridor and Border Governance

Addressing the practical need for regional planning, the spatial-gradient findings—differentiating intermediate-distance corridor belts from localized port-city effects—offer a concrete roadmap for infrastructure prioritization. This guides where regional authorities should target complementary investments, such as dry ports, last-

mile road upgrades, and customs modernization, ensuring that gateway capacity expansions translate into resilient inland spillovers rather than isolated coastal gains.

3. Improved Risk Management and Resilience Assessment

By identifying whether economic activity diversifies across multiple gateways or becomes dependent on a single dominant node, the findings provide a framework for governments and firms to stress-test regional supply chains. This supports proactive diversification strategies to mitigate vulnerabilities to congestion, policy shocks, or geopolitical disruptions.

4. Methodological and Academic Contributions

Academically, the research advances theories of market access, agglomeration, and port competition by detailing how gateway shocks reshape cross-border spatial equilibria. Methodologically, it offers a replicable empirical template—combining harmonized VIIRS night-time lights, continuous exposure measures, event-study DID, and spatial dependence diagnostics—for rigorously evaluating infrastructure impacts in data-constrained, multi-country regions.

Conceptual Framework

1. Conceptual Motivation and Operationalization

This research addresses a core question in economic geography: when trade and transport costs fall, does economic activity concentrate in a small number of dominant nodes (winner-takes-all), or can multiple nodes coexist in a stable, polycentric equilibrium? The Greater Mekong Subregion (GMS) provides a natural laboratory for this question, as inland provinces face competing access to several international gateways.

To operationalize this, we conceptualize the 2015 Sihanoukville Port (SHV) deep-water expansion as a discrete gateway-capacity shock. This shock lowers generalized trade costs and reorders effective market access for connected hinterlands. We measure exposure (treatment intensity) via pre-event road-distance accessibility to SHV, interpreting post-shock effects as a market-access gradient that attenuates with distance and corridor frictions. The resulting spatial equilibrium—whether winner-takes-all concentration or corridor-mediated polycentric diffusion—is captured by the post-2015 reallocation of economic activity, proxied by harmonized VIIRS night-time lights.

2. Theoretical Foundations

Our empirical strategy is grounded in three complementary strands of theory.

1. New Economic Geography (NEG) and Market Access

In NEG, reductions in trade and transport costs trigger spatial reallocations of firms by changing regional market access. Depending on the balance between agglomeration and dispersion forces, a system may move toward core-periphery concentration or maintain a polycentric distribution. In our context, SHV's expansion reduces trade costs for highly connected provinces, directly improving their effective market access.

2. Corridor Economics and Network-Mediated Spillovers

Transport infrastructure generates non-linear spatial responses because benefits transmit through networks. Corridor improvements often create "growth belts" where connectivity gains intersect with complementary inputs. This mechanism suggests that gateway shocks may not concentrate purely at the port city, but rather along intermediate-distance corridors where marginal market-access gains are largest.

3. Port Competition and Hinterland Reconfiguration

In transport economics, gateways continuously compete for hinterland cargo. Capacity expansions can either attract investment away from incumbent gateways (displacement) or enlarge total logistics activity (complementarity). In a multi-gateway region like the GMS, the spatial outcome hinges on whether these connectivity changes generate zero-sum diversion or sustain network expansion across multiple gateways.

3. Core Concepts Used in This Study

To operationalize the conceptual framework (illustrated in the diagram below), we treat the 2015 Sihanoukville Port (SHV) deep-water expansion as a discrete gateway-capacity shock that lowers generalized trade costs and reorders effective market access for connected hinterlands. Following regional economics theory, we measure exposure—or treatment intensity—using pre-event road-distance accessibility to SHV, interpreting post-shock effects as a market-access gradient where gains attenuate with distance and corridor frictions. The resulting spatial equilibrium shift is captured by the post-2015 reallocation of economic activity across the inland provinces, consistently

proxied across borders by harmonized VIIRS night-time lights. Ultimately, this design allows us to rigorously evaluate competing hypotheses: whether the shock produces localized concentration indicative of a winner-takes-all hierarchy, or corridor-mediated diffusion that stabilizes a polycentric, tripolar balance with multiple growth poles in the southern GMS.

4. Conceptual Mechanism and Testable Implications

The conceptual framework implies a corridor-based adjustment mechanism: the discrete SHV capacity expansion disproportionately lowers generalized access costs for provinces with higher pre-event exposure, directly improving their effective market access and logistics feasibility. If this mechanism is operative, it yields distinct testable implications. First, the empirical response must be heterogeneous in exposure intensity; more exposed provinces should experience larger post-2015 increases in economic activity relative to less exposed ones, even after netting out common shocks and time-invariant characteristics. Second, because transmission flows through transport networks, the spatial pattern of gains should be corridor-shaped rather than purely local. Specifically, effects should concentrate along route-aligned, intermediate-distance belts where trade genuinely reorganizes, rather than remaining confined to the port province. Third, this mechanism sharply distinguishes the two spatial equilibrium hypotheses: a winner-takes-all outcome would manifest as extreme localized concentration and diversion from rival gateways, whereas a tripolar balance would appear as a new, complementary growth pole characterized by broader corridor diffusion. Finally, because logistics spillovers inherently propagate across borders, credible inference requires that these estimated post-2015 effects remain robust when explicitly accounting for spatial dependence and alternative definitions of neighborhood connectivity.

5. Key Assumptions

The conceptual framework motivates the empirical strategy under the following assumptions:

1. Relevance of exposure: Pre-event road-distance-based exposure captures meaningful variation in how much provinces benefit from SHV's capacity expansion through changes in generalized access costs.

2. Comparability of outcome proxy: VIIRS night-time lights provide a harmonized measure of relative changes in local economic activity across borders and over time.

3. No differential pre-trends conditional on controls: In the absence of the SHV expansion, high- and low-exposure provinces would have followed similar trends, after accounting for province and year fixed effects and standard controls.

4. Local confounding can be mitigated: Any port-city construction or localized shocks around SHV can be addressed through exclusion (donut) restrictions and robustness checks, allowing the analysis to focus on hinterland reallocation rather than local construction noise.

Research Methodology

1. Study Area and Sample Design

This study focuses on the landlocked and semi-inland hinterland of the Greater Mekong Subregion (GMS) where inland producers can plausibly choose among three competing deep-sea gateways—Laem Chabang (Thailand), Ho Chi Minh City/Cai Mep–Thi Vai (Vietnam), and Sihanoukville (Cambodia). The empirical sample covers 47 inland provinces: 18 in Lao PDR, 18 in Northeast Thailand, and 11 in Cambodia, observed annually from 2012–2021 (balanced panel).

2. Data Sources and Outcome Construction (Night-time Lights)

We use annual VIIRS night-time lights (NTL) as a harmonized proxy for subnational economic activity in a cross-country setting where provincial GDP series are incomplete or not strictly comparable. Provincial outcomes are constructed by overlaying administrative polygons for the 47 provinces onto the VIIRS grid and aggregating radiance values to the province-year level, standard cleaning procedures are applied to address transient light sources and sensor artefacts, with adjustments around known discontinuities.

Main outcome (panel): $y_{it} \equiv \ln(NTL_{it})$

Normalized change outcome (for distance-gradient diagnostics): $\Delta y_{it} \equiv \ln(NTL_{it}) - \ln(NTL_{i,2015})$.

This transformation differences out province-specific levels at the 2015 reference point and is used in non-parametric and donut-gradient checks.

3. Treatment Definition and Exposure Measures

We treat the 2015 deep-water expansion of Sihanoukville Port (SHV) as the policy/infrastructure shock and measure provincial exposure using pre-event road-distance-based accessibility to SHV (and, for benchmarking, to Laem Chabang). The core identification logic is that provinces with higher pre-2015 SHV accessibility should experience larger post-2015 gains if the expansion reconfigures hinterland market access.

We operationalize treatment intensity in two complementary ways:Continuous exposure: $\text{Exposure}_i = \text{Dist}_{i\to\text{SHV}}^{2014}$, road distance in km; lower values imply higher exposure. And distance-band exposure (coarse heterogeneity): provinces are partitioned into mutually exclusive distance bands (near/middle/far), with the far band omitted as reference in event-study DID.

4. Baseline Identification: Dynamic Event-Study DID

To estimate the dynamic impact of the 2015 shock, we implement an event-study DID with province and year fixed effects

(A) Event-study DID with discrete treated group (catchment indicator): $y_{it} = \alpha_i + \gamma_t + \sum_{k\neq -1} \beta_k \left(\mathbb{1}\{t - 2015 = k\} \times \text{Treat}_i \right) + \varepsilon_{it}$

α_i:province fixed effects (time-invariant heterogeneity)

γ_t:year fixed effects (common shocks)

k:event time relative to 2015

Baseline year omitted: k=−1 (2014)

Parallel-trends test: The identifying assumption requires $\beta \approx 0$ for pre-event years.

(B) Event-study DID with continuous exposure (distance intensity):

$$y_{it} = \alpha_i + \gamma_t + \sum_{k\neq -1} \theta_k \left(\mathbb{1}\{t - 2015 = k\} \times \text{Exposure}_i \right) + \varepsilon_{it}$$

Here, θ traces how the slope of the exposure–outcome relationship changes after 2015.

Optional province trends (robustness): $$y_{it} = \alpha_i + \gamma_t + \lambda_i t + \sum_{k\neq -1} \beta_k(\cdot) + \varepsilon_{it}$$

where λit allows province-specific linear trends.

5. Distance-Band Event Study (Interpretability Check)

To provide an easily interpretable heterogeneity profile, we estimate a banded event study:

$$y_{it} = \alpha_i + \gamma_t + \sum_{k \neq -1} \left[\beta_k^N \left(\mathbb{1}\{t - 2015 = k\} \times \text{Near}_i \right) + \beta_k^M \left(\mathbb{1}\{t - 2015 = k\} \times \text{Middle}_i \right) \right] + \varepsilon_{it}$$

The coefficients capture the additional post-2015 change in the near and middle bands relative to the far band.

6. Non-Parametric Distance Gradients (Binned Means)

To avoid functional-form dependence and visualize ripple effects, we construct binned means of by distance to SHV for each year t. Provinces are sorted partitioned into equal-width bins (e.g., 25/50/100 km), and the within-bin mean of is plotted against the bin midpoint. This yields a non-parametric estimate of the spatial decay profile.

7. Donut Regressions: Port-Specific Gradient and Slope Evolution

To summarize the distance gradient compactly and mitigate local construction confounding, we estimate donut-type cross-sectional regressions for post-event years (main text focuses on 2019), excluding provinces within an inner radius around SHV (e.g., 0–100 km):

$$\Delta y_{it} = a_t + \beta_t \cdot \text{Dist}_{i \to \text{SHV}}^{2014} + u_{it}, \qquad i \in \mathcal{D}(\text{donut})$$

8. Spatial Dependence Diagnostics and Robustness Design

Because provinces are connected through corridors and cross-border production networks, outcomes may exhibit spatial autocorrelation. We diagnose this using Global Moran's I with fixed spatial weights over time (e.g., contiguity or KNN), and we check that the main conclusions are not artefacts of a particular neighbour definition.

In robustness, we vary spatial weight matrices (e.g., KNN with different k) and perform influence diagnostics (leave-one-out) to verify that results are not driven by a small number of observations.

Global Moran's I formula: $I = \frac{N}{S_0} \cdot \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}$

where $S_0 = \sum_i \sum_j w_{ij}$ is row-normalized spatial weights.

9. Statistical Inference

We report heteroskedasticity-robust standard errors for cross-sectional donut regressions and cluster-robust standard errors for panel DID/event-study specifications. Where cluster counts are limited, we complement conventional clustering with conservative procedures (e.g., wild bootstrap) and, when appropriate, distance-based spatial corrections for residual correlation.

Research Results

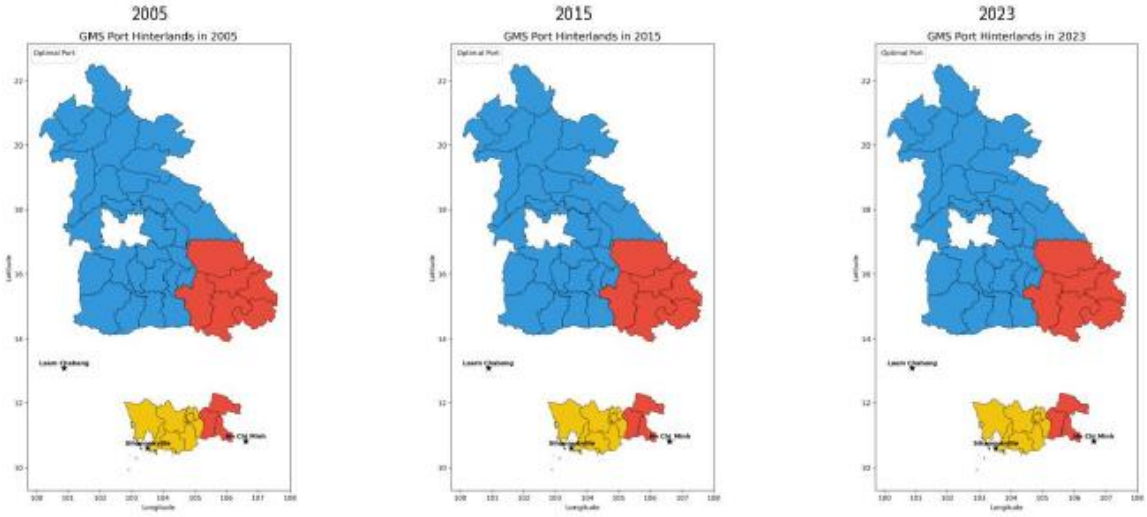


Figure 1 (GMS Port Hinterlands: 2005, 2015, 2023)

The hinterland assignment maps show a persistent tripolar structure in the southern GMS: most inland provinces in Lao PDR and Northeast Thailand remain primarily aligned with Laem Chabang, while Ho Chi Minh City retains a stable catchment over the eastern/southeastern portion of the contested hinterland, and Sihanoukville anchors the western/central Cambodian side of the system. Importantly, the overall partition is remarkably stable between 2005, 2015, and 2023, suggesting that (i) hinterland competition is structured by durable corridor geography rather than short-lived fluctuations, and (ii) any post-2015 reconfiguration associated with SHV is more likely to appear as intensity changes within a broadly stable spatial partition (i.e., growth and corridor spillovers) rather than an immediate, wholesale redrawing of port dominance boundaries.

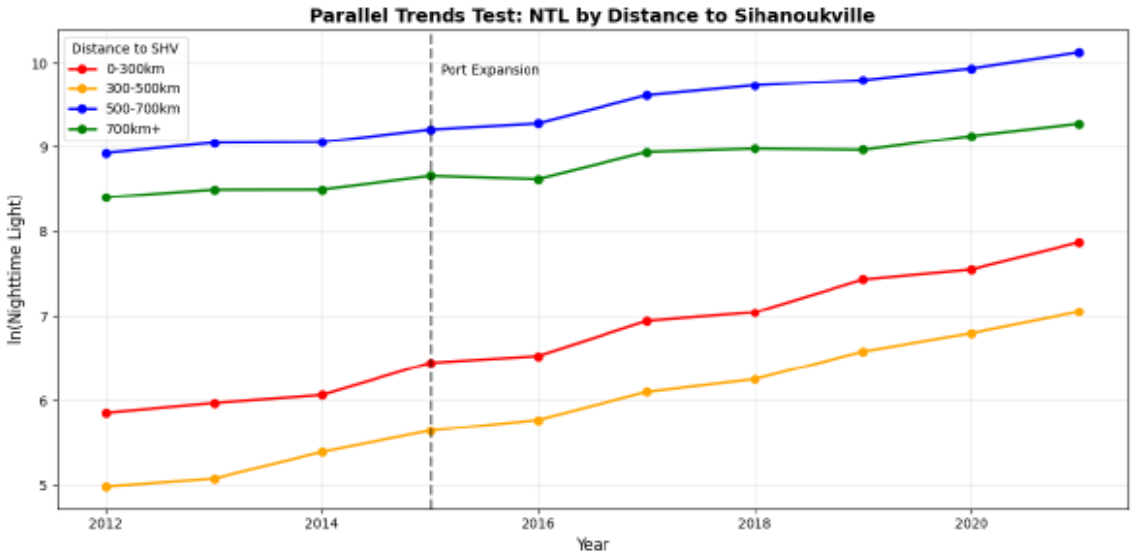


Figure 2 (Parallel Trends Test: NTL by Distance to Sihanoukville)

The distance-binned NTL series provides a transparent diagnostic for the identifying assumption. Prior to 2015, the trajectories of ln (NTL) across distance bands are broadly parallel in slope, indicating no sharp divergence in pre-trends between provinces closer to SHV and those farther away. After the 2015 expansion (vertical dashed line), the lines continue to rise across all groups, but the growth profile becomes more differentiated: the 0–300 km and 300–500 km bands exhibit a clearer post-2015 acceleration relative to more distant groups, consistent with the idea that the SHV capacity shock operated through corridor-linked accessibility and benefited more exposed hinterland locations. This figure therefore supports the event-study DID strategy by showing that the post-2015 divergence is not simply the continuation of a pre-existing differential trend.

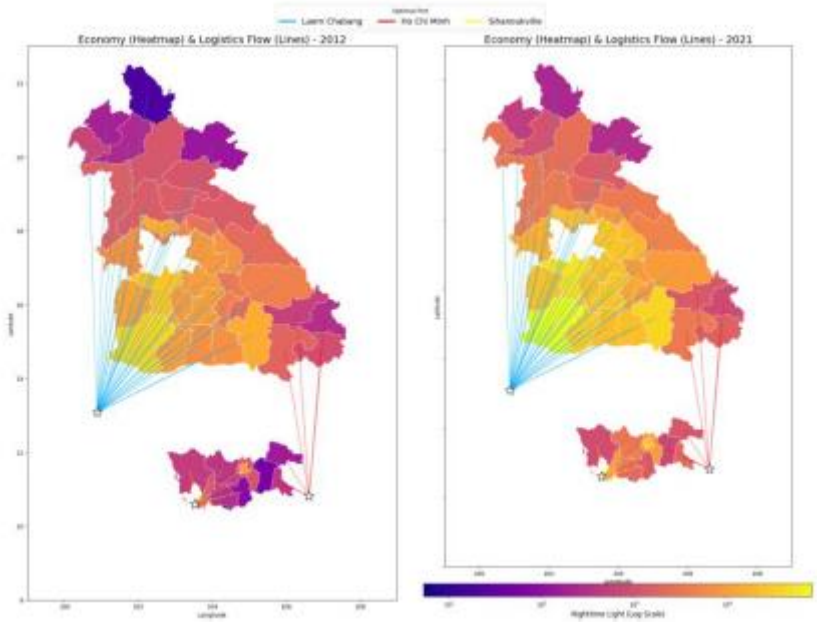


Figure 3 (Economy Heatmap & Logistics Flow: 2012 vs 2021)

Comparing 2012 with 2021, the NTL heatmaps indicate a broad rise in economic activity across the sample, but with a spatial pattern that is strongly corridor-shaped. The interior provinces, especially those lying along the connectivity fan radiating from SHV and linking inland Cambodia and adjacent border areas shift from darker (lower) to warmer (higher) intensity, while the far-periphery changes are more muted. The overlaid logistics flow rays reinforce this interpretation: the post-2015 period is characterized less by a purely local brightening around the port city and more by an inland diffusion pattern aligned with corridor directions. Taken together, the map-based evidence is consistent with network-mediated spillovers, an additional growth pole supported by corridor integration rather than a purely port-city construction effect or a simple, static relocation of the hinterland boundary.

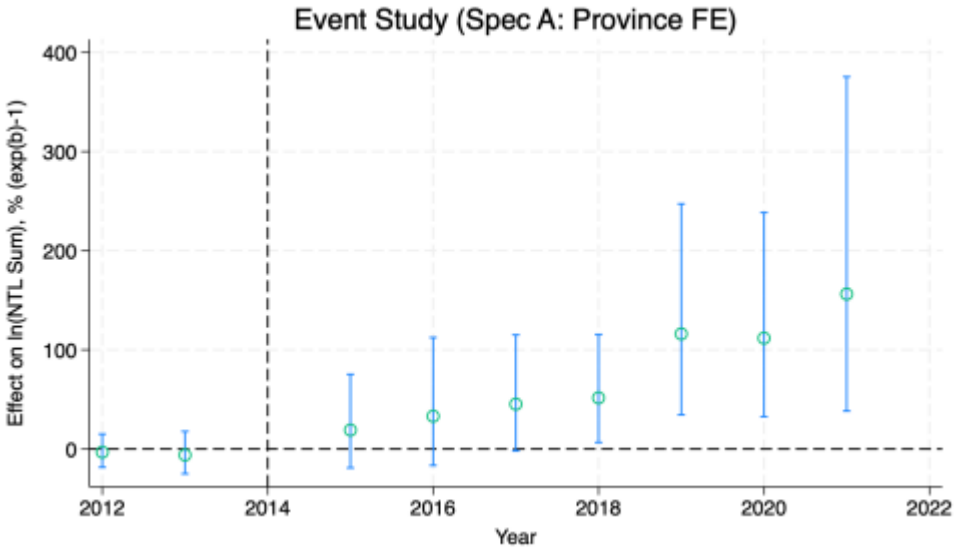


Figure 4: Event Study, Spec A: Province FE

This reports the event-study estimates from Specification A with province and year fixed effects. The pre-treatment coefficients in 2012–2013 are small and statistically indistinguishable from zero, which supports the parallel-trends assumption between the SHV catchment and control provinces prior to the expansion. Beginning in 2015, the estimated effects turn positive and then grow steadily over time. The first post-treatment years (2015–2016) show moderate gains on the order of roughly 20-40 percent higher ln(NTLsum) relative to the 2014 baseline, consistent with an initial adjustment phase in which corridor connectivity and logistics reallocation start to materialize but remain imprecisely estimated (as reflected in relatively wide confidence intervals). From 2017 onward, the effects become both larger and more precisely estimated: coefficients rise into the 50 -120 percent range through the mid-to-late 2010s, and by 2018–2019 the point estimates exceed approximately one additional log point, implying more than a doubling of nighttime lights relative to the counterfactual. The profile continues to increase up to 2021, where the implied effect reaches the order of 150 percent (and, in percentage terms, can amount to several hundred percent depending on the exact coefficient), although the confidence intervals widen as the event window extends further from the treatment year. Overall, Specification A indicates a gradual but sizable build-up of luminosity in SHV catchment provinces, with statistically meaningful gaps

emerging a few years after the expansion and persisting thereafter consistent with a sustained corridor-mediated reconfiguration rather than a one-off, transitory shock.

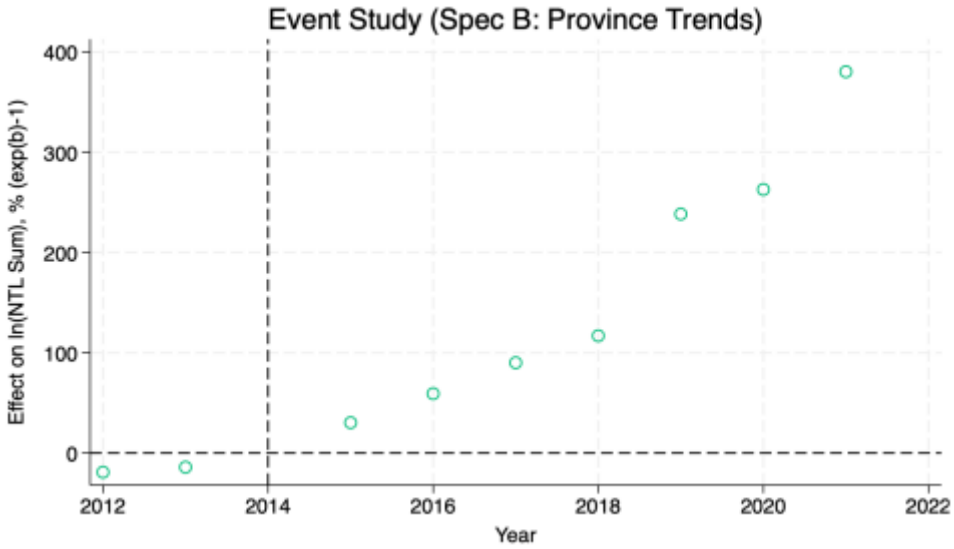


Figure 5: Event Study, Spec B: Province Trends

Figure 5 reports the event-study estimates from Specification B, which extends the baseline model by adding province-specific linear trends so that identification comes from post-2015 deviations relative to each province's own underlying trajectory rather than from level differences alone. The pre-expansion coefficients (2012–2013) remain small and close to zero, providing no evidence of differential pre-trends once province trends are accounted for. Beginning in 2015, the estimated effects turn positive and rise monotonically over time: the early post-treatment years (2015–2016) show moderate gains, the mid-period coefficients (2017–2018) increase further into roughly the 90–120 percent range in $\exp(\beta)-1$ terms, and the late post period displays a pronounced acceleration, with effects around 240–270 percent in 2019–2020 and approaching roughly 380 percent by 2021. Although this specification is more conservative, the persistence and steepening of the post-2015 profile closely mirror the baseline pattern, indicating that the estimated SHV-catchment uplift is not driven by pre-existing province-specific growth paths but reflects a substantial and sustained divergence after the expansion.

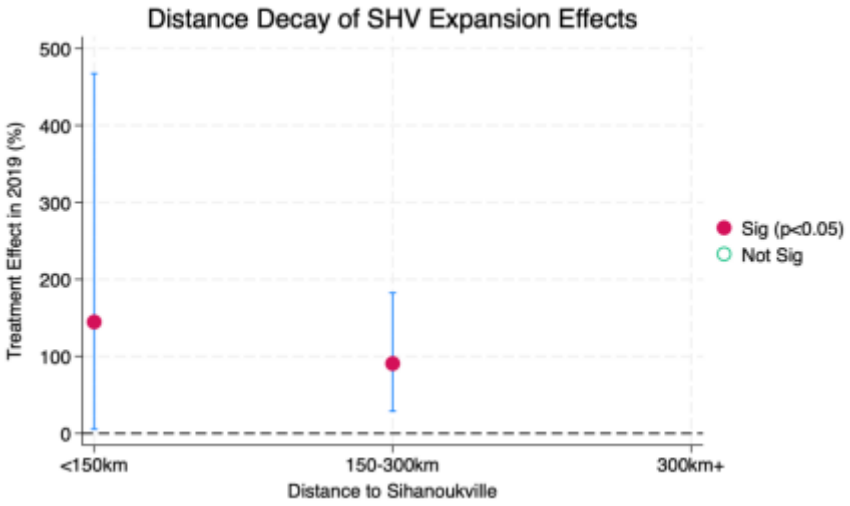


Figure 6. Distance Decay of SHV Expansion Effects

Figure 6 summarizes the spatial decay pattern of the SHV expansion effects by reporting estimated treatment impacts in 2019 across distance bands to Sihanoukville. The results indicate a clear distance gradient: provinces within 150–300 km of SHV exhibit a positive and statistically significant effect ($p < 0.05$), on the order of roughly 90–100 percent, while the <150 km group also shows a positive and statistically significant point estimate of roughly 150 percent but with substantially wider confidence intervals, reflecting greater uncertainty likely driven by fewer observations and the presence of local idiosyncratic factors near the port. By contrast, provinces located beyond 300 km serve as the reference category and show no comparable uplift. Two implications follow. First, the economically meaningful gains are not confined to the immediate port province; instead, the strongest and most precisely estimated effects appear in the intermediate-distance belt, consistent with corridor-mediated spillovers and hinterland reallocation rather than purely local port-city construction activity. Second, the imprecision in the closest band motivates the donut-style restrictions used elsewhere in the analysis to separate localized port-area dynamics from broader hinterland responses.

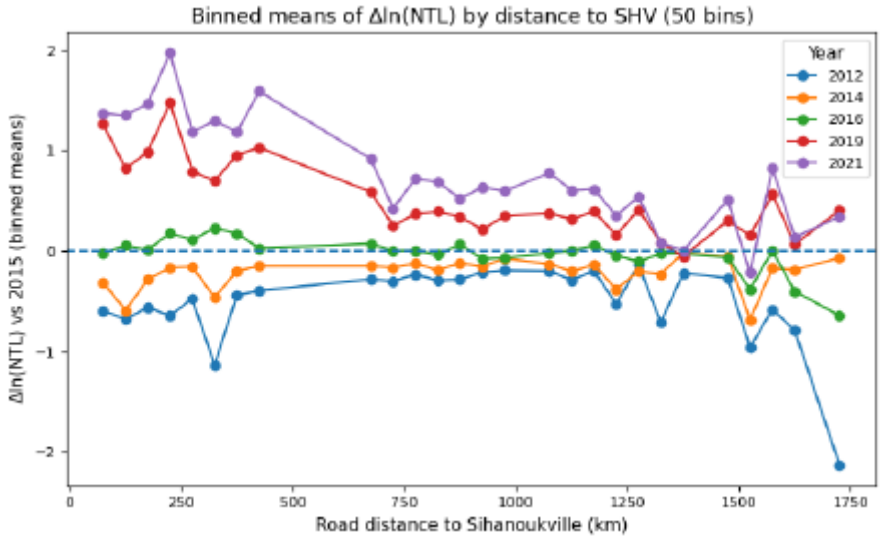


Figure 7. Binned Means of Δln(NTL) by Road Distance to Sihanoukville (50 Bins)

Figure 7 provides a non-parametric view of the distance gradient by plotting binned means of Δln(NTL) relative to the 2015 baseline against pre-event road distance to Sihanoukville (50 bins), separately for selected years. Two patterns stand out. First, the pre-expansion year (2012) lies predominantly below zero across most distances, reflecting lower luminosity relative to 2015 and serving as a visual benchmark for pre-period differences rather than a post-shock response. Second, after the 2015 expansion the profile shifts upward and becomes increasingly positive for later years: the 2016 series is close to zero with modest positive deviations at shorter distances, while the 2019 and 2021 series are clearly above zero over a wide range of distances, indicating substantial post-2015 increases in nighttime lights relative to the 2015 reference level. Importantly, the strongest and most stable positive deviations are concentrated in an intermediate-distance corridor range (roughly a few hundred kilometers to about 1000–1200 km), whereas the farthest distances display greater volatility and occasional negative dips, consistent with thinner bin counts and heterogeneous far-hinterland conditions. Overall, the binned-means evidence supports a corridor-mediated interpretation: the SHV shock is associated with a broad inland uplift that is not confined to the immediate port vicinity and exhibits a distance-decay structure consistent with network spillovers rather than purely local port-city dynamics.

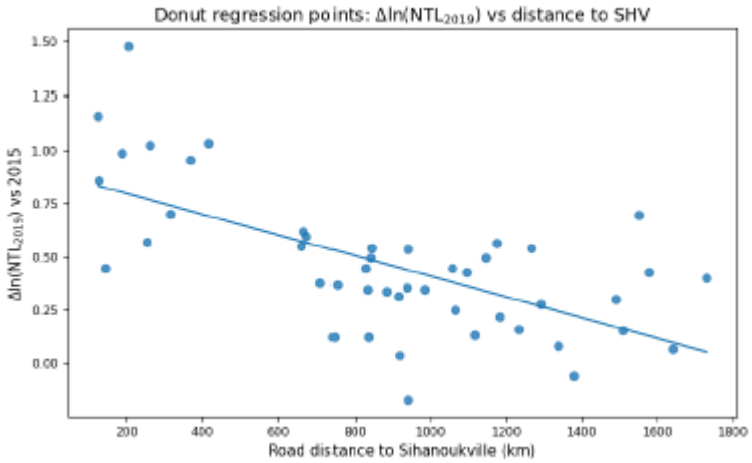


Figure 8. Donut Regression: Δln(NTL2019) vs. Road Distance to Sihanoukville (SHV)

Figure 8 reports the donut-style distance-gradient evidence by plotting province-level changes in luminosity, Δln(NTL2019) relative to 2015, against pre-event road distance to Sihanoukville, together with the fitted linear relationship. The fitted line is clearly downward sloping, indicating that provinces farther from SHV experienced smaller post-2015 gains in nighttime lights by 2019. In other words, conditional on being outside the immediate port area (the "donut" restriction designed to reduce contamination from port-city construction and other highly local shocks), the post-expansion uplift exhibits a systematic distance-decay pattern consistent with a corridor-mediated transmission mechanism: proximity to SHV predicts a larger increase in hinterland economic activity. The scatter also shows meaningful dispersion around the fitted line, which is expected in a cross-border setting where local industrial composition, border frictions, and corridor connectivity vary across provinces; nevertheless, the negative gradient is sufficiently pronounced to support the interpretation that the SHV capacity shock is associated with an inland reallocation/expansion effect that weakens with distance. Taken together with the event-study results and the binned-means profiles, Figure 8 reinforces the view that the post-2015 dynamics are not driven by a purely local port-city shock but reflect a broader spatial response structured by market access and transport-network geography.

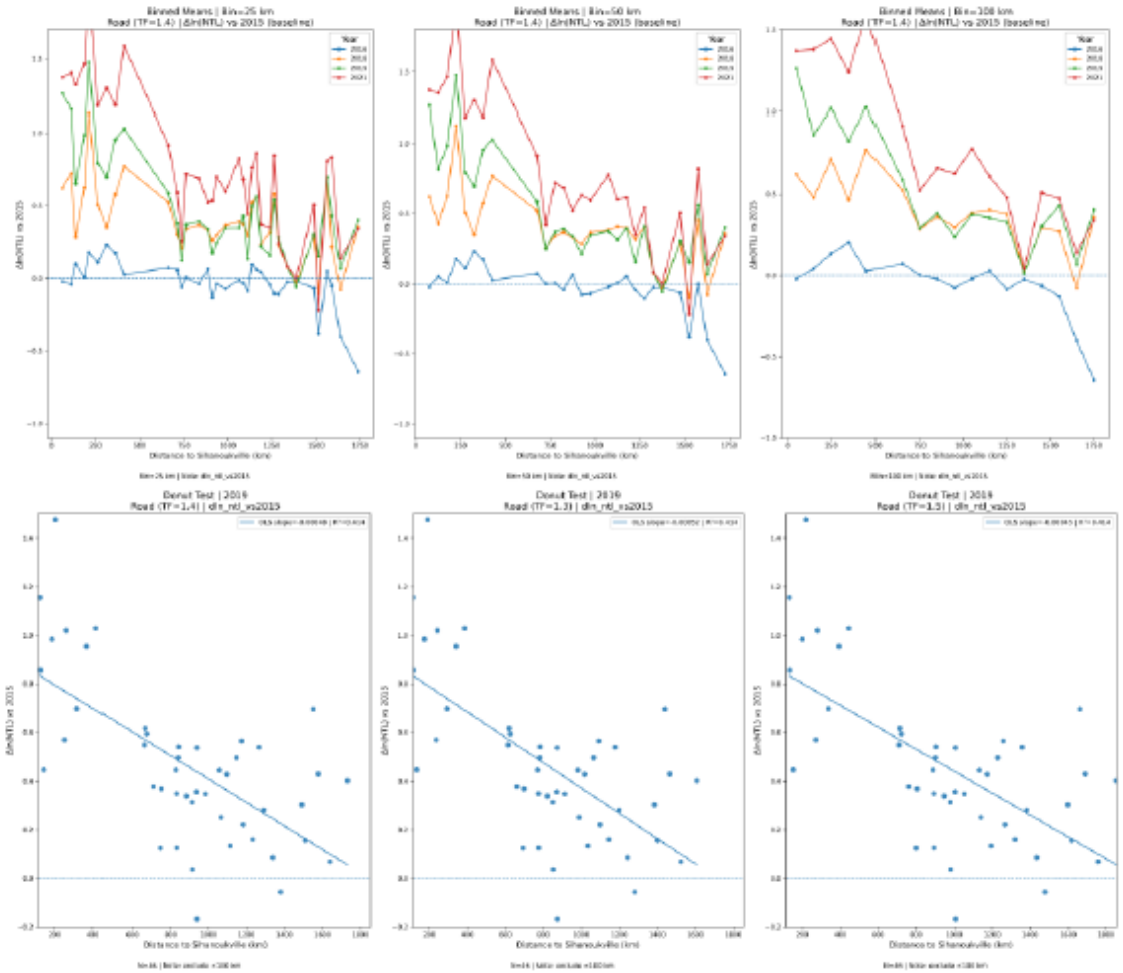


Figure 10. Robustness of the SHV Distance-Gradient: Alternative Binning and Donut Specifications

We bundles two complementary robustness exercises designed to verify that the core "distance-decay" finding is not an artefact of arbitrary smoothing choices or a particular donut cutoff. The top row replicates the binned-means distance profile of Δln(NTL) relative to the 2015 baseline using alternative bin widths (25 km, 50 km, and 100 km). Across all three binning choices, the post-expansion years (especially 2019 and 2021) remain systematically above zero over short-to-intermediate distances and decline as distance increases, while the pre-period series stays near or below zero. The stability of the overall shape across bin widths indicates that the non-parametric gradient is not driven by a particular discretization of distance; rather, the corridor-shaped uplift and its gradual attenuation with distance are a persistent feature of the data.

The bottom row reports donut regressions for 2019 under alternative inner-radius exclusions (e.g., dropping provinces within 1.4, 1.3, or 1.5 units of the cutoff as labeled in the panels). In each case, the fitted relationship between Δln(NTL2019) and road distance to SHV remains clearly negative, implying that provinces farther from SHV experience smaller post-2015 gains even when the immediate port area is excluded. This pattern supports the interpretation that the estimated effects are not dominated by port-city construction activity or highly local shocks near SHV, and it reinforces a network-mediated mechanism in which hinterland gains diffuse along corridors but decay with distance. Taken together, the binning and donut robustness checks strengthen the credibility of the spatial reallocation result: the SHV expansion is associated with a systematic, geographically structured uplift in inland economic activity rather than a fragile pattern sensitive to smoothing or cutoff choices.

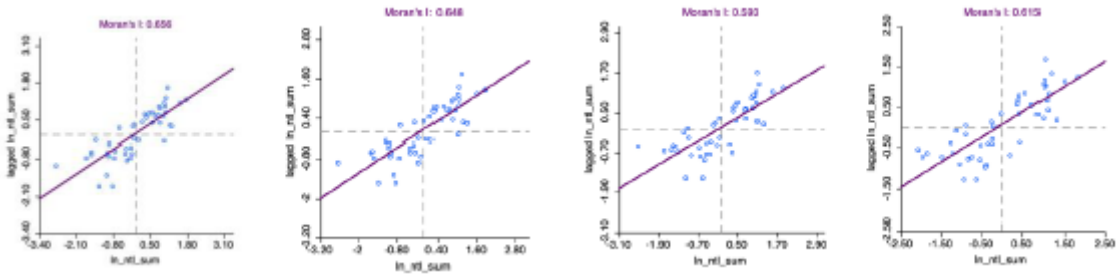


Figure 11. Spatial Autocorrelation in Night-Time Lights: Moran Scatterplots

The Moran's I scatterplots for the log of summed nighttime lights illustrate a consistently high degree of positive spatial autocorrelation across the provinces of the Greater Mekong Subregion (GMS) throughout the sample period. A first concern for our identification strategy is that nighttime economic activity is unlikely to be independently distributed across space. Provinces share production networks, urban systems, and infrastructure corridors, suggesting that both shocks and adjustment may be spatially correlated. To diagnose the extent of such dependence, we compute global measures of spatial autocorrelation in representative pre and post treatment years using a row standardised contiguity matrix that is kept fixed over time.

In 2013, the estimated Moran's I is high at 0.656, indicating that provinces with high NTL tend to be surrounded by neighbors with high NTL, and vice-versa. Similarly, in 2015, the estimated Moran's I remains high at 0.648. In both pre-treatment years, the vast majority of provinces lie in the upper-right (High-High) and lower-left (Low-Low) quadrants of the scatterplots, demonstrating the existence of a highly clustered core–periphery structure before the SHV expansion took full effect. The spatial clustering persists into the post-treatment period, albeit with a slight decline in magnitude, suggesting diffusion of activity. In 2019, the Moran's I is 0.593, and in 2021, it is 0.615. In all years tested, permutation tests robustly reject the null hypothesis of spatial randomness at conventional significance levels. Importantly, the level of global autocorrelation is very similar in the pre-treatment years and only slightly declines as activity diffuses in 2019–2021. This stability in the global Moran's I statistic suggests that the strong spatial correlation is a persistent feature of the GMS urban system—the result of long-term economic geography rather than spurious increase mechanically generated by the highly localized Sihanoukville expansion shock.

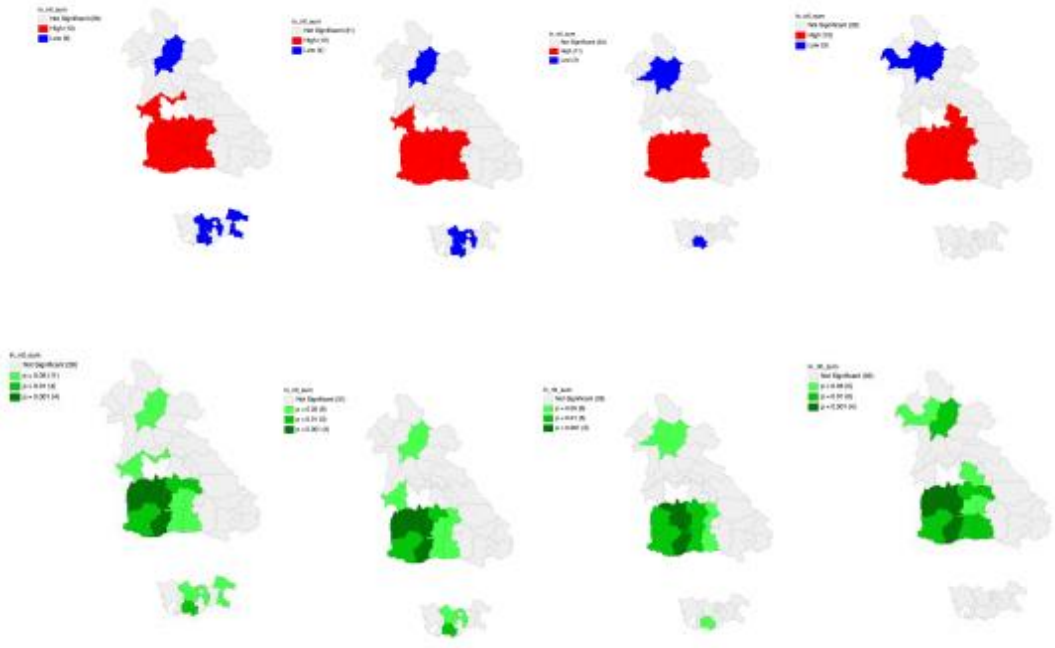


Figure 12. The Local G* for 2013, 2015, 2019 and 2021

Our identification strategy requires explicit attention to spatial dependence, since economic activity and shocks are unlikely to be independent across neighboring

provinces. To diagnose the extent and structure of spatial correlation, we compute global and local measures of spatial autocorrelation using a fixed, row-standardized contiguity matrix. Two persistent features characterize the GMS spatial economy throughout the sample period: a stable High–High cluster concentrated in the central–southern provinces, representing the region's pre-existing urban and manufacturing core aligned with the established logistics axis, and a persistent Low–Low cluster in the northern periphery, reflecting a durable cold spot of remote, underdeveloped provinces consistently distant from major ports and corridor connectivity.

The key evidence relevant to the SHV upgrade emerges from the dynamic adjustment of the High–High boundary over time rather than from changes in the core's location. The 2013 and 2015 patterns are largely similar, indicating that the pre-expansion economic geography was broadly stable, with only modest incremental extension along the existing axis. After the SHV upgrade becomes operational, High–High clustering intensifies and becomes more tightly focused within the central corridor, while several southern coastal provinces near SHV, previously classified as Low–Low or non-significant transition toward non-significant or marginal High–High status. By 2021, the corridor pattern consolidates: a large share of provinces along the projected infrastructure corridor is absorbed into the High–High cluster and Low–Low presence near the southern endpoint declines sharply, consistent with diffusion of increased luminosity toward SHV. This evolutionary pattern directly matches the econometric evidence—explaining the steepening event-study profile after 2016 and the pronounced distance-decay detected in donut regressions while ruling out a generic region-wide boom (which would instead dilute Moran's I and expand High–High clustering uniformly).

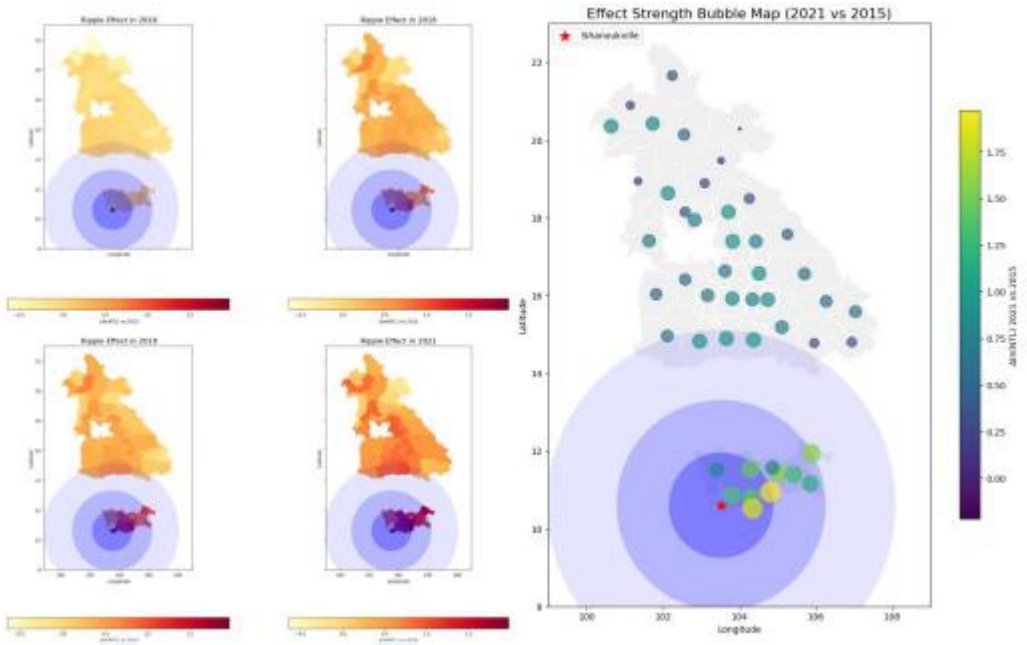


Figure 13. Spatial Diffusion of the SHV Shock

To visualize how the port shock diffuses across space, we combine province-level changes in nighttime lights with concentric distance bands around Sihanoukville and map the resulting patterns for 2016, 2018, 2019, and 2021. A modest halo of higher luminosity appears in coastal Cambodia by 2016, while most of the mainland Mekong remains close to the 2015 baseline; by 2018 the high-intensity areas strengthen and extend inland along the road corridor linking Sihanoukville to Phnom Penh and further north. The 2019 and 2021 panels reveal a clear ripple structure: provinces within the 0–150 km and 150–300 km rings experience the strongest and most persistent gains, whereas areas beyond roughly 300 km exhibit much weaker or no visible change. The 2021 bubble map sharpens this gradient by scaling each province's circle by the magnitude of post-2015 growth, showing dense clusters of large, high-intensity bubbles along the Cambodian coastal belt and adjacent inland provinces, contrasted with small, pale circles in the northern GMS. Finally, a leave-one-out influence diagnostic for the 2021 specification confirms that the estimated effect is not driven by a small number of observations: re-estimating the model while dropping one province at a time yields a tight distribution of coefficients concentrated around 0.35–0.45 (baseline =0.401), with only limited tail outliers, and no single province—aside from the expected leverage of Krong Preah Sihanouk in the extreme donut case—materially overturns the result; if

anything, excluding that port province increases the estimate, reinforcing that the positive NTL response reflects broad-based corridor dynamics rather than idiosyncratic local noise.

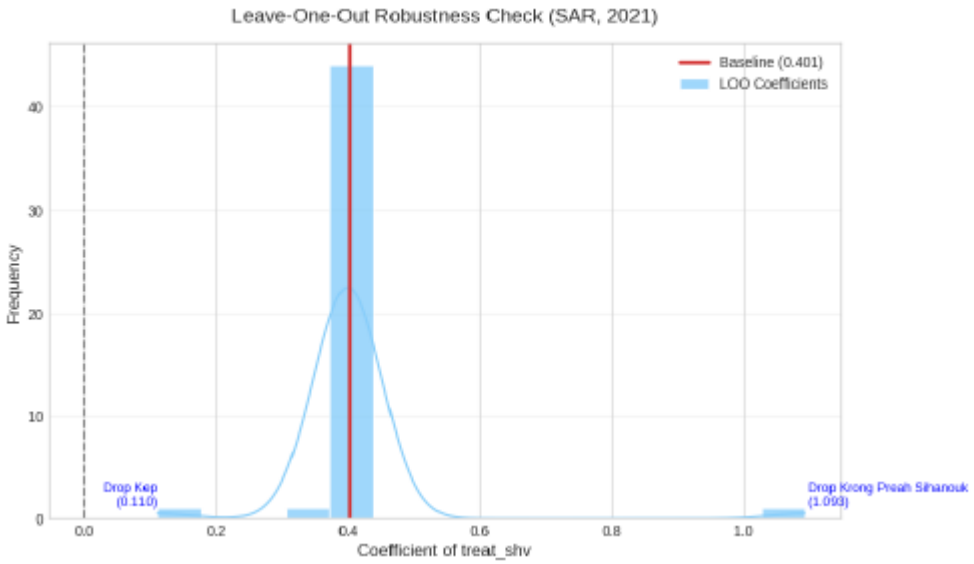


Figure 14. Influence and Donut Robustness

Evaluation sample	Evaluation		
	Coef.	*P-value*	*Significance*
1. Full sample (baseline)	*0.4009*	*0.0075*	***
2. Donut (excl. Krong Preah Sihanouk)	*1.0933*	*0.0000*	***

We next implement a spatial donut test to verify that our estimated port effect is not mechanically driven by the extreme growth of the core port province, Krong Preah Sihanouk. Column (1) of Table Z reports the baseline spatial specification including all provinces, where the estimated treatment coefficient on the Sihanoukville catchment is 0.401 (p-value = 0.0075). Interpreted in levels, this corresponds to roughly a $e^{0.401-1} \approx 49\%$ increase in nighttime lights relative to non-catchment provinces. Column (2) repeats the regression after excluding Krong Preah Sihanouk from the sample; the coefficient rises to1.093 with p-value of 0.00002, implying an effect of almost $e^{1.093-1} \approx 200\%$. The fact that the point estimate becomes larger, rather than collapsing, once the port province itself is removed indicates that the baseline result is not a purely local artefact of the terminal node. Instead, the main gains are realised in the surrounding hinterland provinces, and removing the extreme core observation simply sharpens the contrast between treated and untreated areas.

Summary of the Study

The study identifies a clear and persistent hinterland response to the 2015 Sihanoukville deep-water expansion using provincial VIIRS night-time lights and a multi-period event-study DID design. In the baseline specification with province and year fixed effects, the pre-treatment coefficients (2012–2013) are close to zero, supporting parallel trends, while post-2015 effects turn positive and rise monotonically: early gains in 2015–2016 are moderate (roughly a few tenths of a log point), and the estimated uplift becomes much larger by 2019–2021 (on the order of one log point or more), implying substantial cumulative increases in luminosity in SHV-catchment provinces relative to the counterfactual. The results remain qualitatively robust when adding province-specific trends, suggesting the post-2015 divergence is not explained by pre-existing growth trajectories. Spatial diagnostics further show that the impact is structured by corridor geography rather than being confined to the port city: distance-band and binned-means evidence reveals a post-2015 in dark-to-light reversal in near-to-intermediate distance segments, and donut gradients indicate a statistically meaningful distance decay in 2019. Importantly, excluding the port province does not weaken the effect, if anything, it strengthens supporting the interpretation that the main gains occur in surrounding hinterland provinces. Taken together, the findings imply that SHV's upgrade is better understood as creating an additional growth pole and a new corridor-shaped gradient within the southern GMS, moving the regional gateway system toward a tripolar balance rather than pure displacement of existing gateways.

These results generate two direct directions for further research and policy-relevant extension. First, future work should move from hard road distance to generalized trade costs by explicitly incorporating soft frictions such as customs procedures, border management reforms, and clearance times, which likely mediate how corridor benefits are realized and may change the effective exposure ranking across provinces. Second, the analysis should expand beyond a single-mode road network to multimodal connectivity incorporating inland waterways, rail, and intermodal links to better capture the structural advantages of different gateways (especially the Mekong Delta barge network linked to the HCMC cluster) and to evaluate how new investments (e.g., expressways, rail connections, and cross-border facilitation reforms) reshape the spatial equilibrium. With longer time

series and richer cargo-flow or firm-level data, the current DID/event-study framework can be embedded into spatial econometric or general-equilibrium structures, transforming this paper's empirical baseline into a platform for forecasting corridor strategies and designing governance that institutionalizes polycentric regional balance.

Discussions

The findings are consistent with a market-access and corridor-spillover interpretation from regional economics: a discrete improvement in gateway capacity can shift the spatial equilibrium by strengthening connectivity along specific routes, generating a corridor-shaped uplift rather than a purely local port-city boom. In New Economic Geography, reductions in trade and transport costs can either intensify concentration or sustain multiple nodes depending on the balance between agglomeration and dispersion forces. The stable "core" coupled with a post-2015 elongation of high-activity clusters toward the SHV corridor fits a polycentric adjustment path rather than a winner-takes-all displacement (Krugman, 1991; Fujita, Krugman and Venables, 1999; Redding and Turner, 2015). Crucially, this tripolar stabilization in the GMS provides a contrasting spatial outcome to other regions where transport integration disproportionately drained peripheral activity into a single dominant core, such as the core-periphery divergence observed following China's National Trunk Highway System expansion (Faber, 2014). Empirically, the dynamic DID/event-study profile flat pre-trends and gradually rising post-2015 effects matches the idea that infrastructure shocks operate with lags as firms, logistics providers, and complementary investments adjust over time. This pattern is consistent with spatial adjustments documented in other major transport-infrastructure settings, such as India's historical rail network (Donaldson, 2018). Furthermore, using VIIRS night-time lights provides a defensible cross-country outcome measure in data-scarce regions, and our robustness checks (province trends, donut exclusions, spatial diagnostics, and influence tests) comprehensively address the concern that lights-based work may reflect coincident macro trends or localized construction rather than causal reallocation (Henderson, Storeygard and Weil, 2012; Conley, 1999). Overall, the evidence supports an interpretation of the SHV upgrade as the formation of an additional growth pole that strengthens corridor-mediated integration while preserving a tripolar port–

hinterland structure an outcome with direct implications for governing connectivity investments to stabilize polycentric regional development.

Recommendations

To sustain a stable polycentric equilibrium rather than intensifying zero-sum port competition, corridor governance must be treated as a joint cross-border outcome. GMS policymakers should coordinate "soft" facilitation—such as customs modernization and cross-border trucking regimes with "hard" complementary infrastructure, like dry-port development and strategic industrial-zone placement along intermediate-distance belts. Crucially, while our spatial specification yields a highly significant coefficient of 1.093 (excluding the port province), which mathematically translates to a roughly 198% relative increase in local light intensity ($e^{1.093}-1 \approx 1.983$), policymakers must interpret this magnitude with caution. This figure captures a relative statistical reallocation of spatial economic activity driven by network spillovers, rather than an absolute 198% macroeconomic expansion in provincial GDP. Consequently, regional planning should utilize these findings to guide the directional placement of multi-gateway hedging strategies, avoiding the exaggeration of point estimates for absolute growth targets.

Because the same gateway shock transmits through distinct domestic institutions and border frictions, future research should be explicitly organized around the differing constraints of Cambodia, Lao PDR, and Thailand. For Cambodia, the immediate next step is to pair NTL-based results with micro-evidence from the SHV Phnom Penh corridor, such as firm entry, special economic zone (SEZ) activity, and industrial land conversion to isolate logistics-led production reallocation from localized urban construction. For Lao PDR, a landlocked economy arbitraging competing gateways, future studies should replace simple geographic distance with generalized trade costs to test whether the SHV corridor meaningfully alters Laos's optimal gateway choice relative to Laem Chabang and Vietnamese ports. Finally, for Thailand, with Laem Chabang as a dominant incumbent and the Northeast as the contested hinterland, future research should quantify whether SHV's rise produces zero-sum diversion or resilience-enhancing complementarity. Ultimately, a three-country extension should explicitly model how different combinations of

infrastructure and policy interventions best institutionalize regional balance as a stable spatial equilibrium.

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A Causal Relationship Model of Entrepreneurial Orientation Market Orientation and Competitive Advantage Influence of Business Performance of Construction in the Central Region of Thailand

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Abstract

In this thesis, the researcher examines (1) examine the influence of entrepreneurial orientation, market orientation, and competitive advantage on the business performance of construction firms in the central region of Thailand; (2) confirm the structural relationships among entrepreneurial orientation, market orientation, competitive advantage, and business performance of construction firms in the central region of Thailand; and (3) develop a causal relationship model of entrepreneurial orientation, market orientation, and competitive advantage affecting the business performance of construction firms in the central region of Thailand. The study focuses on four key constructs: entrepreneurial orientation, market orientation, competitive advantage, and business performance. A quantitative research approach was employed. Data were collected from 300 construction companies through questionnaires administered to business owners or their representatives. Descriptive statistics and Structural Equation Modeling (SEM) using the AMOS program were applied for data analysis. The findings indicated that entrepreneurial orientation, market orientation, and competitive advantage were at the highest level, while business performance was at a high level, with the internal process perspective rated the highest. The results further showed that entrepreneurial orientation, market orientation, and competitive advantage had significant positive effects on business performance. All hypothesized relationships were supported at the 0.05 level of significance.

Keywords: entrepreneurial orientation, market orientation, competitive advantage, business performance

Background and Statement of the problem

The construction industry is a key driver of Thailand's economic development, contributing significantly to infrastructure expansion, employment generation, and linkages with related sectors such as real estate, manufacturing, finance, and logistics. In alignment with Thailand's National Economic and Social Development Plan and the 20-Year National Strategy, the industry plays a crucial role in enhancing national competitiveness through technology, innovation, and large-scale infrastructure investment (Anupan, 2015; Nuttavut & Sumalee, 2021).

In 2022, Thailand had 141,586 registered construction firms, with the highest concentration located in the Central Region, reflecting its economic significance (GSB Reserch, 2023). Construction investment was divided between the public sector (58%) and private sector (42%), with public projects primarily focused on infrastructure development, particularly within the Eastern Economic Corridor (EEC) (Krungsri Research, 2022). Although the industry shows signs of recovery and projected growth between 2022–2027, it continues to face substantial challenges, including project delays, rising material costs, labor shortages, inflation, and financial liquidity constraints—especially among small and medium-sized contractors.

Moreover, rapid digital transformation and technological advancement are reshaping construction processes, compelling firms to adopt modern management systems and performance measurement tools such as the Balanced Scorecard (BSC) to improve operational efficiency and competitiveness (Krungsri Research, 2022). These structural and environmental changes have pressured construction firms to rethink their strategic and operational approaches. Firms are increasingly integrating advanced technologies into construction processes to enhance productivity, while simultaneously adjusting marketing strategies to align with evolving customer expectations. Emphasis on environmental responsibility and cost efficiency has also become essential for sustaining and expanding competitive positions in a highly dynamic market (Nichakan Lunkhunthod et al., 2022). Nevertheless, disparities in financial capability, technological readiness, and strategic management practices between large and smaller contractors may hinder sustainable growth and limit the development of long-term competitive advantage.

Therefore, this study examines the relationships among entrepreneurial orientation, market orientation, and competitive advantage within construction businesses in Thailand's Central Region. The findings aim to provide strategic guidance for enhancing long-term competitiveness and sustainable growth in both public and private construction markets.

Objective

1. To examine the influence of entrepreneurial orientation, market orientation, and competitive advantage on the business performance of construction firms in the central region of Thailand.
2. To confirm the structural relationships among entrepreneurial orientation, market orientation, competitive advantage, and business performance of construction firms in the central region of Thailand.
3. To develop a causal relationship model of entrepreneurial orientation, market orientation, and competitive advantage affecting the business performance of construction firms in the central region of Thailand.

Expected benefits

1. At the governmental level, the findings offer guidelines for data integration, innovation promotion, and enhancing transparency in public construction projects.
2. At the business level, the results support firms in improving competitiveness, creating business value, enhancing operational efficiency, and reducing construction costs in response to economic conditions.
3. At the academic level, the study contributes to the body of knowledge and provides a conceptual framework for future research and teaching in construction business studies, particularly within the context of Thailand's central region.

Conceptual Framework

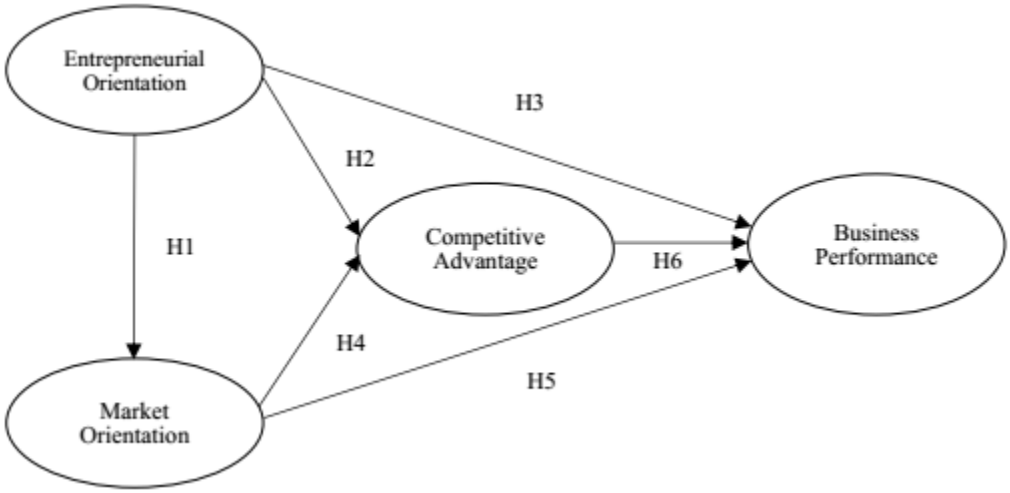


Figure 1: Conceptual Framework of Entrepreneurial Orientation, Market Orientation, Competitive Advantage, and Business Performance

Research Methodology

This study employed a quantitative research approach. The population consisted of 28,805 construction firms in the central region of Thailand, based on the Department of Business Development (2026). The unit of analysis was the organization. The sample size was determined based on the criteria of Comrey and Lee (1992), in which 300 samples are considered "good" for factor analysis and structural equation modeling (SEM). A total of 300 construction firms were selected using probability sampling through multi-stage sampling, including stratified random sampling and proportional allocation across 12 provinces in the central region. The sampled firms were required to be actively operating in the construction sector in the central region of Thailand, engaging in both residential and non-residential construction projects. Respondents were business owners or assigned executives. Data were collected using structured questionnaires. Content validity was examined using the Index of Item-Objective Congruence (IOC ≥ 0.50), and reliability was confirmed with Cronbach's alpha coefficient (α ≥ 0.70). Data were analyzed using descriptive statistics and Structural Equation Modeling (SEM) with AMOS. The independent variable was entrepreneurial orientation. Market orientation and competitive advantage were mediating variables, and business performance was the dependent variable.

Research Results

Table 1 Mean, standard deviation, coefficient of variation, skewness, and kurtosis of the constructs

Constructs	Mean	Standard Deviation	%CV	SK	KU
Entrepreneurial Orientation (EO)	4.239	0.526	12.405	-1.113	1.390
Market Orientation (MO)	4.256	0.471	11.074	-1.168	1.446
Competitive Advantage (CA)	4.295	0.449	10.463	-1.095	1.598
Business Performance (BP)	4.171	0.515	12.355	-0.995	0.994

The descriptive analysis of entrepreneurial orientation, market orientation, competitive advantage, and business performance of construction firms in the central region of Thailand indicated that all constructs were rated at a high level. Competitive advantage reported the highest mean value (Mean = 4.295), followed by market orientation (Mean = 4.256) and entrepreneurial orientation (Mean = 4.239), while business performance showed the lowest mean (Mean = 4.171), though still at a high level. The skewness and kurtosis values were within acceptable ranges, indicating that the data were approximately normally distributed, as shown in Table 1.

Table 2 Correlation coefficient matrix between variables

Constructs	Entrepreneurial Orientation (EO)	Market Orientation (MO)	Competitive Advantage (CA)	Business Performance (BP)
Entrepreneurial Orientation (EO)	1.000			
Market Orientation (MO)	0.795**	1.000		
Competitive Advantage (CA)	0.732**	0.713**	1.000	
Business Performance (BP)	0.748**	0.797**	0.740**	1.000

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.846, Bartlett's Test of Sphericity = 1,054.358, df = 6, p-value = 0.000, **p < 0.010

The results from analyzing the correlation coefficients between the variables of the structural equation model of entrepreneurial orientation, market orientation, competitive advantage, and business performance of construction firms in the central region of Thailand showed that all correlation coefficients were significance at 0.01 level. All pairs of variables had positive relationships, ranging from 0.713 to 0.797. The pair with the highest correlation coefficient was the relationship between market orientation and business performance, with a coefficient of 0.797. The pair with the lowest correlation coefficient was the relationship between market orientation and competitive advantage, with a coefficient of 0.713 Therefore, all relationships were statistically significant at the 0.01 level, as shown in Table 2.

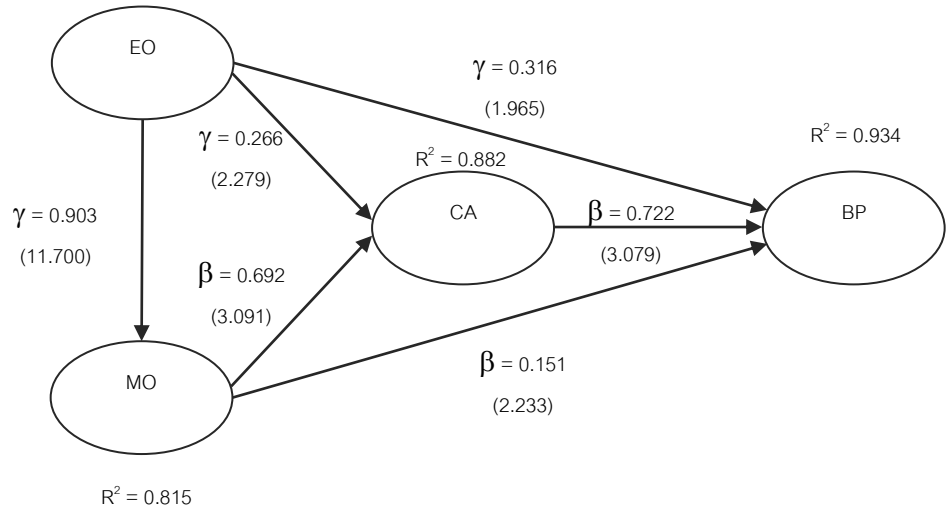


Figure 2: Structural equation model of the causal relationships affecting business performance of construction in the central region of Thailand.

Table 3 Estimating the direct and indirect influence of causal factors affecting the business performance of construction in the central region of Thailand

Antecedent Variables	Endogenous Variables								
	MO			CA			BP		
	DE	IE	TE	DE	IE	TE	DE	IE	TE
EO	0.903	-	0.903	0.266	0.624	0.891	0.316	0.598	0.914
MO	-	-	-	0.692	-	0.692	0.151	0.499	0.650
CA	-	-	-	-	-	-	0.722	-	0.722
R-Square	0.815			0.882			0.934		

The results from structural equation modeling (SEM) showed the structural relationships affecting the business performance of construction firms in the central region of Thailand. The causal influence line from the entrepreneurial orientation (EO) affected the business performance (BP) with a value of 0.316. The causal influence line from the entrepreneurial orientation (EO) affected the market orientation (MO) with a value of 0.903. The causal influence from the market orientation (MO) to the business performance (BP) had a value of 0.151. The causal influence line from the entrepreneurial orientation (EO) affected the competitive advantage (CA) with a value of 0.266. The competitive advantage (CA) affected the business performance (BP) with a value of 0.722. Furthermore, the market orientation (MO) affected the competitive advantage (CA) with a value of 0.692.

Furthermore, the results from analyzing the standardized path coefficients of the causal components of the structural equations showed that the entrepreneurial orientation (EO) had the highest total effect (TE) of 0.914 on business performance (BP). Next, the competitive advantage (CA) had a total effect (TE) of 0.722. The market orientation (MO) had a total effect (TE) of 0.650 on business performance (BP), respectively. The coefficient of determination (R^2) showed that the model explained 0.815 of the variance in MO, 0.882 of CA, and 0.934 of BP, as shown in Figure 1 and Table 3.

In addition, the analysis of indirect effects revealed that competitive advantage (CA) plays a significant mediating role in the relationship between entrepreneurial orientation (EO) and business performance (BP). Entrepreneurial orientation positively influences competitive advantage (β = 0.266), which in turn has a strong positive effect on business performance (β = 0.722). The indirect effect of entrepreneurial orientation on business performance was 0.598, indicating a partial mediation effect.

Similarly, market orientation (MO) also contributes indirectly to business performance through competitive advantage. Market orientation significantly affects competitive advantage (β = 0.692), which subsequently enhances business performance. The indirect effect of market orientation on business performance was 0.499, further supporting the mediating role of competitive advantage.

These findings highlight that competitive advantage serves as a key mechanism through which both entrepreneurial orientation and market orientation improve business performance.

By analyzing the path coefficients of the causal components of the structural equations, The results of hypothesis testing in the quantitative study are presented in Table 4.

Table 4 Results of research hypothesis testing

Path Diagram	Path Coefficients	CR *(t-value)*	P-value	Conclusion
EO → MO	0.903	11.700	0.001	Supported
EO → CA	0.266	2.279	0.05	Supported
EO → BP	0.316	1.965	0.05	Supported
MO → CA	0.692	3.091	0.001	Supported
MO → BP	0.151	2.233	0.05	Supported
CA → BP	0.722	3.079	0.001	Supported

Hypothesis 1: Entrepreneurial orientation influences market orientation. The hypothesis was supported by statistical analysis, which found a path coefficient of 0.903 and a t-value of 11.700, with a significant level of 0.001. This indicates that placing

emphasis on entrepreneurial orientation has a strong positive impact on market orientation within an organization.

Hypothesis 2: Entrepreneurial orientation influences competitive advantage. The hypothesis was supported by statistical analysis, which found a path coefficient of 0.266 and a t-value of 2.279, with a significant level of 0.05. This suggests that entrepreneurial orientation positively affects competitive advantage within the organization.

Hypothesis 3: Entrepreneurial orientation influences business performance. The hypothesis was supported by statistical analysis, which found a path coefficient of 0.316 and a t-value of 1.965, with a significant level of 0.05. This indicates that entrepreneurial orientation has a positive impact on business performance.

Hypothesis 4: Market orientation influences competitive advantage. The hypothesis was supported by statistical analysis, which found a path coefficient of 0.692 and a t-value of 3.091, with a significant level of 0.001. This suggests that market orientation positively contributes to competitive advantage.

Hypothesis 5: Market orientation influences business performance. The hypothesis was supported by statistical analysis, which found a path coefficient of 0.151 and a t-value of 2.233, with a significant level of 0.05. This indicates that market orientation has a positive effect on business performance.

Hypothesis 6: Competitive advantage influences business performance. The hypothesis was supported by statistical analysis, which found a path coefficient of 0.722 and a t-value of 3.079, with a significant level of 0.001. This suggests that competitive advantage has a strong positive impact on business performance.

Summary of the Study

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This study aimed to examine the causal relationships influencing business performance of construction businesses in the central region of Thailand. The key variables included entrepreneurial orientation, market orientation, competitive advantage, and business performance.

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included entrepreneurial orientation (EO), market orientation (MO), competitive advantage (CA), and business performance (BP).

The results indicated that entrepreneurial orientation had a significant positive influence on market orientation. This finding demonstrates that organizations emphasizing proactiveness, innovativeness, and risk-taking tend to strengthen their market-oriented behaviors by actively responding to customer needs and market changes. Furthermore, entrepreneurial orientation positively influenced competitive advantage. This suggests that organizations with strong entrepreneurial characteristics are more capable of creating differentiation, developing innovative solutions, and sustaining competitive positions in dynamic market environments. In addition, entrepreneurial orientation had a positive effect on business performance, indicating that proactive and innovative management contributes to improved operational efficiency, profitability, and long-term organizational outcomes.

The results indicated that entrepreneurial orientation had a significant positive influence on market orientation. This finding demonstrates that organizations emphasizing proactiveness, innovativeness, and risk-taking tend to strengthen their market-oriented behaviors by actively responding to customer needs and market changes. Furthermore, entrepreneurial orientation positively influenced competitive advantage and business performance. Crucially, the findings reveal that competitive advantage (CA) serves as a key mediator that bridges the influence of entrepreneurial orientation (EO) toward business performance (BP). This suggests that while having an entrepreneurial vision is vital, proactiveness and innovativeness alone may not directly translate into superior performance. Instead, these entrepreneurial characteristics act as a catalyst for the firm to first develop distinct differentiation or cost leadership strategies. This "competitive superiority" then functions as a bridge, transforming entrepreneurial energy into tangible profitability and long-term organizational sustainability.

The study also found that market orientation positively influenced competitive advantage. This implies that focusing on customer needs, competitor analysis, and internal coordination enhances an organization's ability to build sustainable advantages and adapt effectively to industry changes. Moreover, market orientation positively affected business performance, showing that market-driven strategies contribute to improved operational effectiveness, customer satisfaction, and financial results. Lastly, competitive

advantage had a strong positive influence on business performance. This indicates that differentiation, cost leadership, and niche market strategies significantly enhance overall business performance and organizational sustainability.

In the specific context of the current Thai construction industry, which faces multi-faceted challenges such as volatile and rising material costs as well as severe skilled labor shortages, the roles of EO and MO become even more critical. The study implies that entrepreneurial and market-driven firms are better equipped to adapt promptly to these external pressures. For instance, by adopting innovative construction technologies to reduce labor dependency or implementing proactive supply chain management to control material costs, firms can enhance their cost-based competitive advantage.

Overall, the findings confirm that entrepreneurial orientation serves as a fundamental driver that strengthens market orientation and competitive advantage, which in turn lead to improved business performance. These results highlight the importance of strategic management practices in achieving sustainable growth in the construction industry.

Overall, the findings confirm that entrepreneurial orientation serves as a fundamental driver that strengthens market orientation and competitive advantage, which in turn leads to improved business performance. These results highlight the importance of strategic management practices in achieving sustainable growth and maintaining operational resilience within the Thai construction sector amidst a highly dynamic and demanding economic environment.

Discussions

The findings of this study provide empirical evidence of the significant relationships among entrepreneurial orientation, market orientation, competitive advantage, and business performance in construction businesses in the central region of Thailand.

First, entrepreneurial orientation was found to have a strong positive influence on market orientation. This result indicates that organizations characterized by proactiveness, innovativeness, and risk-taking behaviors are more likely to develop strong market-oriented practices. In the context of the construction industry, where competition is intense and

market conditions change rapidly, entrepreneurial firms tend to actively seek new opportunities in both public and private sectors. As a result, they are required to analyze customer needs, monitor competitors, and coordinate internally to reduce risk and enhance success. This finding is consistent with Idrus et al. (2020), Octavia et al. (2020) and Paitoon and Kittisak (2020), who reported that entrepreneurial orientation directly strengthens market orientation by encouraging firms to respond strategically to market dynamics. Second, entrepreneurial orientation positively influenced competitive advantage. This suggests that organizations emphasizing innovation and proactive decision-making are better positioned to differentiate their products and services. In construction businesses, differentiation may occur through project quality, innovative techniques, or specialized expertise. This finding aligns with Karnowati et al. (2022), Pratikshya et al. (2022), Fatikha et al. (2021), Artarina and Deni (2019) and (Nuttavut & Sumalee, 2021), who found that entrepreneurial orientation enhances a firm's ability to create unique value and sustain competitive advantage. Moreover, entrepreneurial orientation had a positive impact on business performance. This indicates that firms that actively pursue innovation and accept calculated risks are more capable of improving operational efficiency, controlling costs, and increasing customer satisfaction. These improvements ultimately contribute to both financial and non-financial performance. The result supports prior studies by Neni Dyah and Avanti (2025), Abdullah Hamoud Ali (2025), Abdullahi et al. (2023), Triani and Yeni (2023), Karnowati et al. (2022), Nursal et al. (2022), Pratikshya et al. (2022), Karimi et al. (2021), Octavia et al. (2020) and (Paitoon & Kittisak, 2020), which confirm the direct relationship between entrepreneurial orientation and firm performance. In addition, market orientation significantly influenced competitive advantage. This finding supports the concept proposed by Narver and Slater (1990), which emphasizes that customer orientation, competitor orientation, and interfunctional coordination are fundamental elements of sustainable competitive advantage. Organizations that continuously collect market information and adapt strategies accordingly can respond effectively to customer demands and environmental changes. This result is consistent with Karnowati et al. (2022), Fatonah and Haryanto (2022), Fatikha et al. (2021) and Winarso et al. (2020), who found that market orientation directly enhances competitive positioning. Furthermore, market orientation positively affected business performance. This indicates that organizations

that prioritize customer satisfaction and competitor analysis can improve service quality, increase customer loyalty, and expand their customer base. Such improvements ultimately lead to higher revenue and profitability. These findings are consistent with Zhou et al. (2026), Triani and Yeni (2023), Wucheng et al. (2022), Nursal et al. (2022), Octavia et al. (2020) and Paitoon and Kittisak (2020). Finally, competitive advantage was found to have a strong positive influence on business performance. This result confirms Porter's (1980) theory that differentiation, cost leadership, and focus strategies are essential determinants of superior performance. Construction firms that successfully differentiate their services, control costs efficiently, or focus on niche markets are more likely to win projects, retain customers, and achieve sustainable profitability. This finding is consistent with Karnowati et al. (2022), Pratikshya et al. (2022) and Abeysekara et al. (2019), who emphasized that competitive advantage directly enhances organizational performance. Overall, the discussion highlights that entrepreneurial orientation acts as a foundational strategic capability that strengthens market orientation and competitive advantage, which subsequently drive business performance. In a highly competitive and dynamic construction environment, firms must integrate entrepreneurial behavior with market-driven strategies to achieve sustainable growth and long-term success.

Recommendations

Construction firms should prioritize entrepreneurial orientation as a core strategic driver to enhance business performance. Managers should emphasize proactiveness, innovativeness, and calculated risk-taking to identify emerging opportunities, improve operational efficiency, and ensure long-term sustainability. Firms should also strengthen competitive advantage through cost efficiency, service differentiation, and niche market positioning. In the context of the Thai construction industry, firms are increasingly facing challenges such as rising material costs, labor shortages, and supply chain disruptions. These external pressures require firms to enhance their competitive advantage by improving cost control, adopting innovative construction technologies, and optimizing resource management. The adoption of modern construction technologies, systematic project management, and recognized quality and safety standards can enhance organizational credibility and performance. Continuous development of market orientation

is equally important. Systematic customer analysis, competitor monitoring, and effective internal coordination—supported by digital tools and market intelligence—can improve decision-making, customer satisfaction, and market expansion.

Government agencies should support innovation capability, technological adoption, and safety standards to enhance industry competitiveness. Public–private collaboration and knowledge-sharing platforms should be promoted to improve project efficiency and strategic coordination. Private sector organizations should invest in workforce development, digital transformation, and sustainable construction practices. Strategic partnerships with suppliers and industry stakeholders can strengthen resource integration and long-term competitiveness.

The findings reinforce the importance of entrepreneurial orientation as a strategic capability that drives market orientation, competitive advantage, and business performance. The results highlight the interconnected relationships among these key variables in strengthening organizational outcomes within the construction industry. Future research may explore additional dimensions of entrepreneurial orientation, examine the role of digital technologies in construction management, and extend the framework to related industries or different stakeholder groups to enhance generalizability and further theoretical development.

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A Study of Causal Factors, Knowledge Management, and Technology Adoption for Corporate Social Responsibility in the Electric Vehicle Industry toward Sustainability

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Abstract

This study focuses on personal factors, causal factors, and knowledge management, and their influences on the adoption of technology for corporate social responsibility (CSR) within the electric vehicle (EV) industry toward sustainability. The sample group consists of 400 EV users in Thailand, with data collected via questionnaires. Statistical analyses included frequency, percentage, analysis of observed variables, measurement models, and structural equation modeling (SEM) using the Partial Least Square (PLS) method.

The results indicate that personal factors significantly affect causal factors in knowledge management, which in turn influence technology adoption for sustainable EV business operations. Both measurement and structural equation models confirmed the consistency of the research framework with empirical data across all indicators. These findings assist businesses in identifying strengths and weaknesses, leading to the formulation of appropriate policies and strategies to create added value for both businesses and society in the long term.

Keywords: Knowledge management, Technology acceptance, Corporate Social Responsibility (CSR), Sustainability

Background and Statement of the problem

In an era of rapid technological advancement and increasing environmental awareness, electric vehicles have become an attractive option for consumers and the automotive industry. The shift from internal combustion vehicles to electric vehicles impacts technology and the market and deeply concerns social dimensions and sustainability. The electric vehicle business is not limited to the production and distribution of vehicles but also requires knowledge management related to this new technology to continuously develop products and services that meet the needs of customers and society. In addition, the acceptance of technology by employees and executives is an important factor affecting the success of the business and also affects the organization's social responsibility Manner, P., Tikka, V., Honkapuro, S., Tikkanen, K., & Aghaei, J. (2024), EKumar, R. (2024), Zhang, Y., Lu, M., & Shen, S. (2021), Sovacool, B. K., Kester, J., Noel, L., & Zarazua de Rubens, G. (2020),Bello, A. N., Sogunro, E. O., & Adeniyi, M. (2024),Mulyono. (2024). Research gaps Despite the large amount of research on EVs, there are still several interesting research gaps, including the link between knowledge management and social responsibility. Most research focuses on the technological and economic factors of EVs. However, relatively little research still studies the link between organizational knowledge management and social responsibility in EV businesses. The influence of technology acceptance. Most research studies the factors affecting consumer technology acceptance. However, limited research still studies the influence of technology acceptance by employees and executives within organizations on social responsibility. Sustainability in the context of the EV business: Although EVs are seen as a sustainable option, issues still need to be considered, such as battery waste management and the impact of EV parts production on the environment. Arsih, V., & Animah. (2024), Nwachukwu, C., et al. (n.d.),Sivarajah, U., Irani, Z., Gupta, S., & Mahroof, K. (2020), Talbot, D., Raineri, N., & Daou, A. (2021), Roos, N., & Guenther, E. (2020), Ponte, S. (2020), Budur, T., Abdullah, H., Rashid, C. A., & Demirer, H. (2023). Interesting research This research is interesting because it answers current challenges. This research helps to understand the factors that affect the EV business's success and the industry's sustainability. Create new knowledge. This research will help fill the gap and create new knowledge about the link between knowledge management, technology adoption, and social responsibility, leading to improved operations. The research results can be used to improve the knowledge management process within the organization and

encourage employees and executives to participate in innovation and develop the business for sustainable growth. 16. Yumhi, Y., Dharmawan, D., Febrian, W. D., Sutisna, A. J., & Syahribulan. (2024),Nakash, M., & Bouhnik, D. (2024),Prameswari, N. H. R., Habibah, N. M., Chorer, M. M., & Mun, M. A. S. (2024),Hamid, N., Munizu, M., & Mardiana, R. (2024),Farooq, R. (2024),Patwary, A. K., Alwi, M. K., Rehman, S. U., Rabiul, M. K., Babatunde, A. Y., & Alam, M. M. D. (2024),Nazarian, A., Shahzad, M., Ding, X., & Appolloni, A. (2024),Athaillah, T., Aulia, M. R., & Shalwati. (2024). Expected Impacts The results of this research are expected to have impacts in many areas, including Organizational level: helping EV business organizations to develop more effective knowledge management processes, encourage employees to accept new technologies, and create an organizational culture that emphasizes social responsibility; Industrial level: helping the automotive industry develop good practices in knowledge management and promoting sustainability; Social level: helping society realize the importance of developing EVs and related technologies, and promoting sustainable development; Kapser, S., & Abdelrahman, M. (2020),Sohn, K., & Kwon, O. (2020). The researchers attempted to complement the linkage of knowledge management, technology adoption, and social responsibility in the context of the EV business. This will help to better understand the overall picture of sustainable EV industry development, leading to guidelines for knowledge management development and technology adoption promotion that will lead to socially responsible business operations in the EV industry. The research results may lead to appropriate policies and strategies for entrepreneurs, investors, and the government to support sustainable and socially responsible EV industry development.

Objective

1. This study focuses on personal factors, causal factors, knowledge management, and influences on the adoption of technology for the social responsibility of the EV business toward sustainability

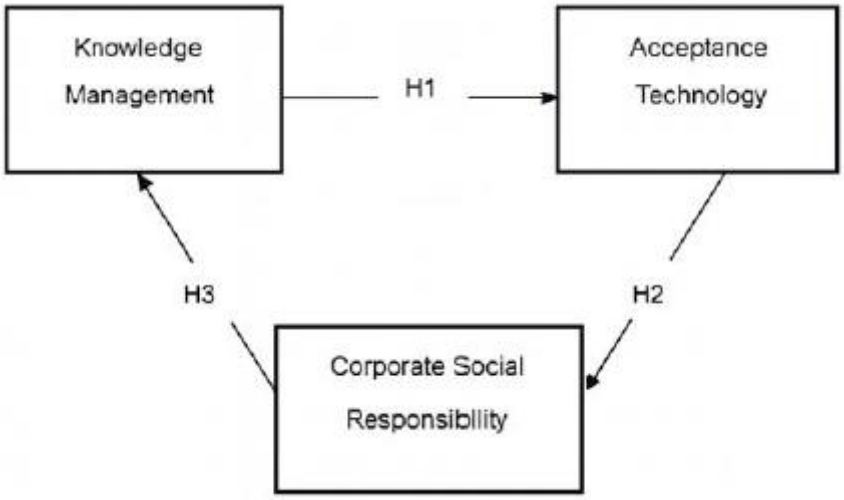
Research hypothesis

1. Knowledge management influences technology adoption in the electric vehicle business.

2. Knowledge management influences the social responsibility of the electric vehicle business.

3. Knowledge management influences the social responsibility of the electric vehicle business.

Conceptual Framework



Research Methodology

Research Instrument Validation

1. Content Validity: The questionnaire was developed and submitted to the independent research advisor to ensure content coverage aligned with the research objectives. Four experts in research instrumentation subsequently evaluated the items for completeness and consistency. They provided suggestions to refine the language for more direct and appropriate communication. The Index of Item-Objective Congruence (IOC) was then calculated, resulting in a perfect consistency index of 1.00.

2. Reliability Testing: To ensure a rigorous research process, the reliability of the instrument was tested with a non-sample population of 40 individuals. Using Cronbach's Alpha Coefficient formula, the analysis yielded a reliability score of 0.87, confirming the high internal consistency and thoroughness of the research methodology.

Data Collection

The researcher collected primary data using a questionnaire distributed to a sample group of 400 electric vehicle (EV) users in Bangkok. To ensure the feasibility of data collection within the target population, a convenience sampling method was employed.

Data Analysis

The statistics used in analyzing the data in this research included frequency, percentage, mean, standard deviation, and structural equation modeling (SEM) using PLS-SEM data analysis.

Research Results

Demographics

Population and sample used in the research

Population is a company listed on the Stock Exchange of Thailand

The sample group consists of 400 customers who use electric vehicles in Bangkok, selected using a convenience sampling method.

Descriptive Statistics

The statistics used in analyzing the data in this research included frequency, percentage, mean, standard deviation, and structural equation modeling (SEM) using PLS-SEM data analysis

Table 1 Frequency percentage

Variable		Frequency	Percentage
sex	Male	212	53.00
	Female	188	47.00
status	Single	198	49.50
	Married	171	42.80
	Divorced/Widowed	20	5.00
	Separated	11	2.80
age	Under 30 years old	203	50.70
	30 - 49 years old	176	44.00
	50 - 59 years old	14	3.50
	60 years old and above	7	1.80
education	Below bachelor's degree	102	25.50
	Bachelor's Degree	298	74.50
occupation	Students	47	11.80
	Private company employees	234	58.50
	Civil servants/State enterprises	45	11.30
	Traders	51	12.80
	Farmers	15	3.80
	Others	8	2.00
income	Less than or equal to 20,000 baht	37	9.30
	20,000 – 30,000 baht	219	54.80
	30,001 – 40,000 baht	48	12.00
	More than 40,000 baht	96	24.00
Electric vehicle usage experience	Already have an electric car	38	9.50
	Deciding to buy	132	33.00
	Someone recommended to buy	105	26.30
	Have family member use	55	13.80
	Have friend use	62	15.50
	Other	8	2.00
Residing	Bangkok	134	33.50
	perimeter	133	33.30
	Other	133	33.30

Discussion

Objective 1: To analyze the measurement model of causal factors of knowledge management influence of technology adoption towards social responsibility of electric vehicle business. This research is crucial in understanding the complex relationship between these factors and their influence on the adoption of technology for social responsibility in the electric vehicle business

(Coefficient determinant)

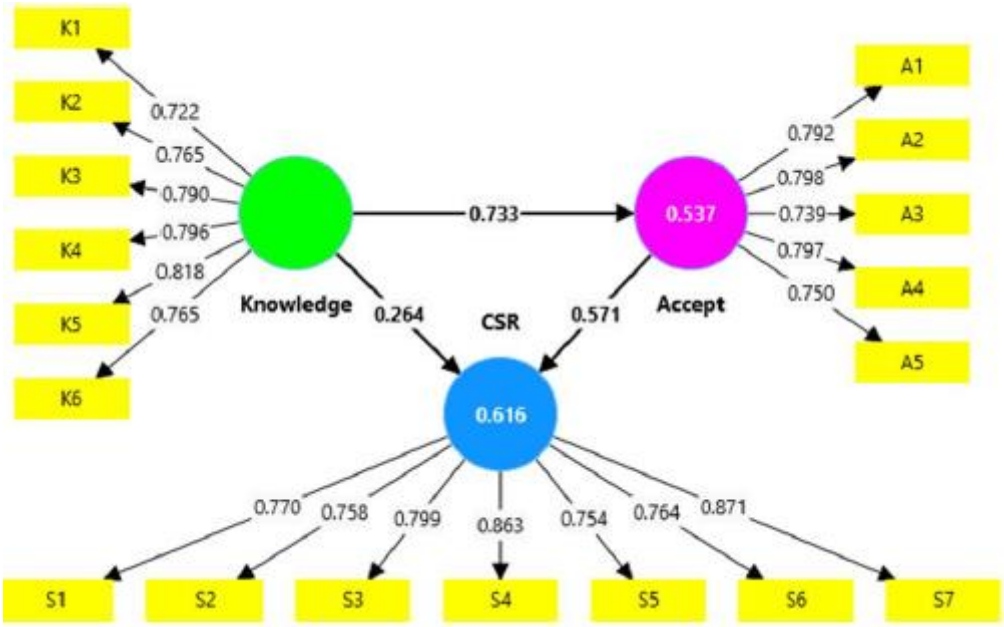


Figure 2 Measurement model

From the analysis of the influence between the dependent and independent variables, it can be explained by the proportion of the variance of the endogenous latent variable that is explained by the independent variable, the coefficient of prediction of the endogenous latent variable R2 or R-Square, where R2 should be no less than 0.25. It is considered that the independent variable can explain the variance in the dependent variable. The research results found that the variables of knowledge management, technology acceptance, and corporate social responsibility of electric vehicle companies have a coefficient of prediction higher than 0.25, indicating that the independent variable can explain the variance in the latent variable.

Table 2 Outer Loading Matrix

	Accept	CSR	Knowledge
A1	0.792		
A2	0.798		
A3	0.739		
A4	0.797		
A5	0.750		
K1			0.722
K2			0.765
K3			0.790
K4			0.796
K5			0.818
K6			0.765
S1		0.770	
S2		0.758	
S3		0.799	
S4		0.863	
S5		0.754	
S6		0.764	
S7		0.871	

(Outer loading)

The standardized outer loading of indicator variables should be less than 0.70. If it is lower than this, the variable should be considered. Table 3 shows the weights of external components. All indicator variables have outer loading greater than 0.7. Therefore, it can be concluded that all indicator variables used in the study are reliable.

Partial Least Square Structural Equation Modeling Results and Discussion.

Objective2: To analyze the structural equation of the causal factors of knowledge management influence of technology acceptance towards social responsibility of electric vehicle business

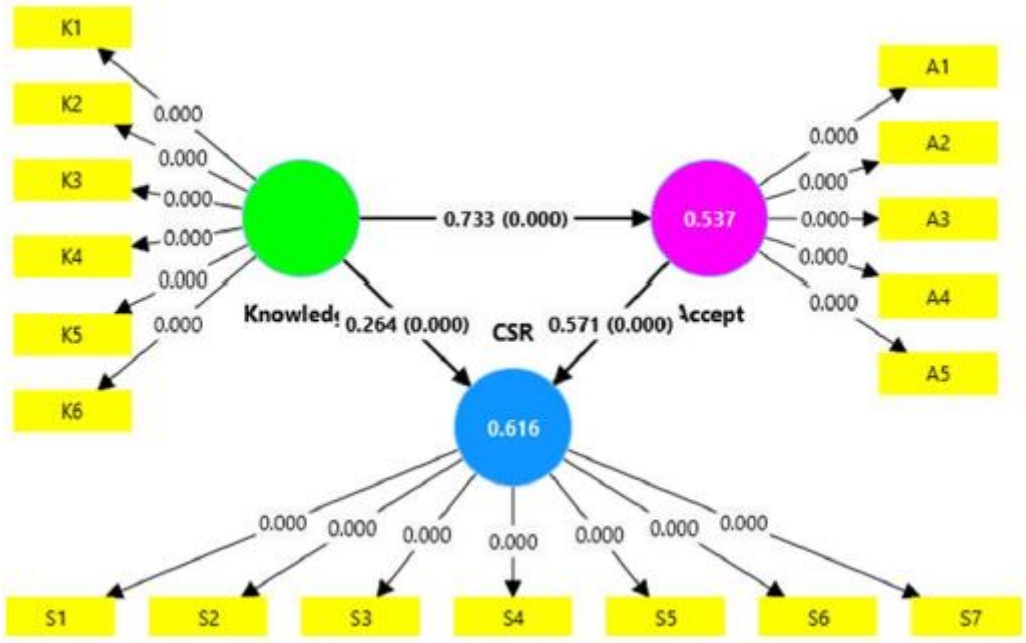


Figure 3 The PLS Structural model Knowledge, Corporate Social responsibility, Accepted

Hypothesis testing for structural model evaluation by PLS-SEM method uses the statistical significance test of parameters by Bootstrapping process. It uses the hypothesis test with two-tiled rejection zone. The coefficient has a significance level of 0.05, i.e. $p<0.05$ and t-Statistics is greater than the path coefficient supporting the research hypothesis. It can be explained according to the relationship group as follows

Objective 3: To develop a model of causal factors of the electric vehicle business towards sustainability.

A robust sustainability analysis model for the electric vehicle business should encompass economic, social, and environmental dimensions. Internationally recognized models, such as the Triple Bottom Line (3P) model that considers Profit, People, and Planet, or the United Nations' SDG (Sustainable Development Goals) model, which emphasizes the 17 Sustainable Development Goals, can be applied. Additionally, specialized models, like the Life Cycle Assessment model to assess environmental impacts throughout the product's lifecycle, or the Value Chain Analysis model to analyze added value and points that create positive or negative impacts in the supply chain, can be integrated for a comprehensive approach

Discussion

Conducting a sustainability analysis of the electric vehicle business can yield significant benefits. It can help businesses identify their strengths, weaknesses, opportunities, and obstacles in sustainable business operations. The finding that social responsibility carries the highest weight in technology acceptance aligns with the research of Kapser and Abdelrahman (2020) and Sohn and Kwon (2020), who emphasized that risk perception and intelligent product features are key drivers of user acceptance. Furthermore, the significant impact of KM on business sustainability is consistent with the findings of Budur et al. (2023), which highlight the essential role of knowledge processes in achieving sustainability goals. The study also supports the views of Nazarian et al. (2024), who identified green innovation and knowledge management as vital components for sustainable development.

Table 3 Research Hypothesis

Research hypothesis		T-statistics	Test results
H1	Knowledge management influences the adoption of EV technology in the business	11.119	support
H2	Knowledge management influences the social responsibility of electric vehicle business	25.054	support
H3	Technology adoption influences the social responsibility of electric vehicle businesses	4.957	support

Comment *** p<0.01, **p<0.05

Conclusion

It was found that the aspect of social responsibility had the highest weight in accepting the technology of the electric vehicle business, followed by the aspect of social responsibility of the electric vehicle business and the aspect of knowledge management of the electric vehicle business, in which all components and indicators passed the criteria for checking the consistency of empirical data.

Practical Implications

The research results indicate that the knowledge management model significantly influences the adoption of EV technology towards sustainability, especially in terms of social

responsibility, which has the highest weight. This means that knowledge management related to EV technology, such as sharing knowledge about environmental impacts, building community networks, or developing environmentally friendly products, will help businesses gain more social acceptance. In addition, adopting information technology also plays an important role in driving changes toward sustainability, reflecting the importance of using technology to manage knowledge and promote collaboration within the organization.

The research also found that although knowledge management in the EV business has the lowest weight, it is an equally important factor. Having a systematic and effective knowledge management system will allow businesses to access information related to EV technology quickly and easily, resulting in more efficient decision-making and operations.

In conclusion, the knowledge management model plays an important role in driving the adoption of EV technology towards sustainability, affecting social responsibility, information technology adoption, and EV business knowledge management. Therefore, focusing on knowledge management is essential for businesses that want to grow sustainably in the era of EVs. In line with research Kapser, S., & Abdelrahman, M. (2020), Sohn, K., & Kwon, O. (2020).

Additional recommendations

Emphasize the importance of social responsibility: There should be clear communication about environmentally and community-friendly operations.

Promote the use of information technology: Use technology to manage knowledge, such as creating a database, using AI to analyze data, or creating a platform for knowledge sharing.

Develop a knowledge management system: Create a systematic and efficient system to provide employees with easy access to relevant information.

Policy Implications

Knowledge management models' policy implications on EV technology adoption are significant. Having a strong and effective knowledge management model will help promote the exchange of knowledge and dissemination of EV technology knowledge more widely, which will lead to the development of policies that facilitate the acceptance and adoption of

this technology more widely, such as the formulation of policies to promote the production and use of EVs, the creation of charging infrastructure, and the support of research and development of related technologies. In addition, knowledge management enables government and private agencies to coordinate and work together more effectively to achieve the goal of promoting the use of EVs and reducing the impact on the environment in the long term.

Limitations and Future Research Directions

Future research should focus on developing intelligent and flexible knowledge management systems and establishing learning communities to promote knowledge and experience exchange so that knowledge management can more effectively support the development of electric vehicles and achieve sustainability goals.

Data Availability

The necessary data should cover both technical aspects, such as battery performance, price, production costs, and environmental impacts, as well as social aspects, such as consumer attitudes, government policies, and charging infrastructure. In addition, quantitative data related to sales, energy consumption, and greenhouse gas reductions are also necessary to assess the impact of this technology. However, this data may be scattered in various sources and in different formats. Therefore, collecting and analyzing this data requires appropriate tools and techniques, such as data mining and quantitative analysis, to obtain reliable results and use them to develop measures to promote the use of electric vehicles.

Acknowledgement

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The Utilization of Accounting Information for Business Forecasting among Small and Medium Enterprises (SMEs) in Nong Khaem District, Bangkok

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Abstract

This study is a quantitative research project aimed at investigating the effective utilization of accounting information for business forecasting within small and medium enterprises (SMEs). Data were collected via questionnaires from a sample group of 400 participants, consisting of executives, supervisors, and accountants from SMEs registered in Nong Khaem District, Bangkok. The statistical analysis employed Stepwise Multiple Regression Analysis to test the hypotheses.

The findings indicate that the utilization and analysis of accounting information-specifically data from income statements, statements of financial position, and statements of cash flows, along with trend analysis and financial ratio analysis-significantly contribute to business forecasting for SMEs in Nong Khaem. The adjusted coefficient of determination (Adjusted R Square), used to compare models with varying numbers of predictors, was 0.802. This suggests that these variables can collectively explain 80.2% of the positive influence on effective business forecasting. The specific accounting components utilized for forecasting, in order of statistical significance (at the 0.05 level), include: trend analysis (b=.528), financial ratio analysis (b=.261), income statement data (b=.180), balance sheet data (b=.099), and statement of cash flows (b=.088).

Keywords: Accounting Information, Business Forecasting, Trend Analysis, Financial Ratio Analysis

Introduction

In today's rapidly evolving global society, the application of accounting information in business forecasting has been a long-standing practice. Since the early stages of commerce, entrepreneurs have sought to predict the future of their enterprises to facilitate strategic planning and critical decision-making, such as investments, business expansion, or tactical adjustments. Amidst highly competitive economic conditions and swift technological advancements, businesses require tools that support informed, reliable, and accurate decision-making. Accounting data—including financial statements, income statements, and cash flow statements—are widely recognized as essential resources for analyzing and predicting future financial performance.

When businesses integrate these data points into business forecasting to anticipate future impacts, such as revenue growth, cost control, or cash flow management, they can develop appropriate strategic plans and better navigate market uncertainties. Regarding Informed Decision-Making, accounting information enables management to analyze financial performance and make rational choices, particularly in forecasting profits or future revenue-generating capacity. Furthermore, in terms of Risk Management, the use of accounting data assists in assessing investment or operational risks through cash flow forecasting, solvency analysis, and the calculation of financial ratios, thereby evaluating the business's resilience against unforeseen circumstances. For Long-term Business Planning, forecasted accounting information empowers businesses to execute effective long-term strategies, specifically concerning business expansion, new project investments, or strategic partnership decisions.

Currently, Thai SMEs account for 95% of all enterprises and contribute to over 50% of total employment. SMEs are therefore vital for job creation, income generation, and serve as the foundation for large-scale business development. Approximately 99.5% of entrepreneurs in Thailand—totaling about 2,000,000 entities—are SMEs. While the primary GDP drivers are approximately 2,000 large-scale enterprises, SMEs involve a larger portion of the population, supporting roughly 70% of employment. Most SME production (70%) is sold domestically, with 30% for export, indicating that the primary market for SMEs is domestic.

The primary challenges for Thai SMEs lie in inefficient management and administration, particularly regarding organizational management, finance, accounting, marketing, and human resources. A core issue is the lack of accounting information utilization for management, specifically for forecasting and decision-making. In the current climate of intense economic competition, survival depends on high efficiency. Consequently, new entrepreneurs entering highly competitive markets face significant operational difficulties. Research indicates that accounting information plays a crucial role in executive decision-making, especially in cost planning and sales forecasting. In SMEs, it was found that executives utilize accounting information for various decisions at a high level, where data quality (relevance and comparability) directly influences decision-making efficiency.

Potential issues include incomplete or inaccurate data; accounting information used for forecasting must maintain high precision, as errors can lead to flawed business decisions. Additionally, forecasting relies heavily on assumptions regarding factors such as market growth, inflation, or changes in government policy; incorrect assumptions can result in forecasts that do not align with reality. Challenges also arise from Big Data management, where analyzing complex accounting datasets can be difficult, especially amidst rapid fluctuations. Furthermore, Technological Adaptation requires continuous updates to accounting systems, necessitating investment in new tools to meet modern forecasting demands.

Given the aforementioned circumstances, the researcher is interested in studying the utilization of accounting information for business forecasting. This study is of paramount importance as it aims to enhance the competitive advantage of these enterprises, enabling entrepreneurs to make precise strategic decisions and establish long-term financial stability. Furthermore, it serves as a guideline for promoting and developing business potential at both local and national levels.

Research Objectives

1. To investigate the utilization of various types of accounting financial statements and financial statement analysis for business forecasting among small and medium-sized enterprise (SME) entrepreneurs in the Nong Khaem District.

2. To study the application of accounting information and data analysis for effective business forecasting among small and medium-sized enterprise (SME) entrepreneurs in the Nong Khaem District.

Expected Benefits

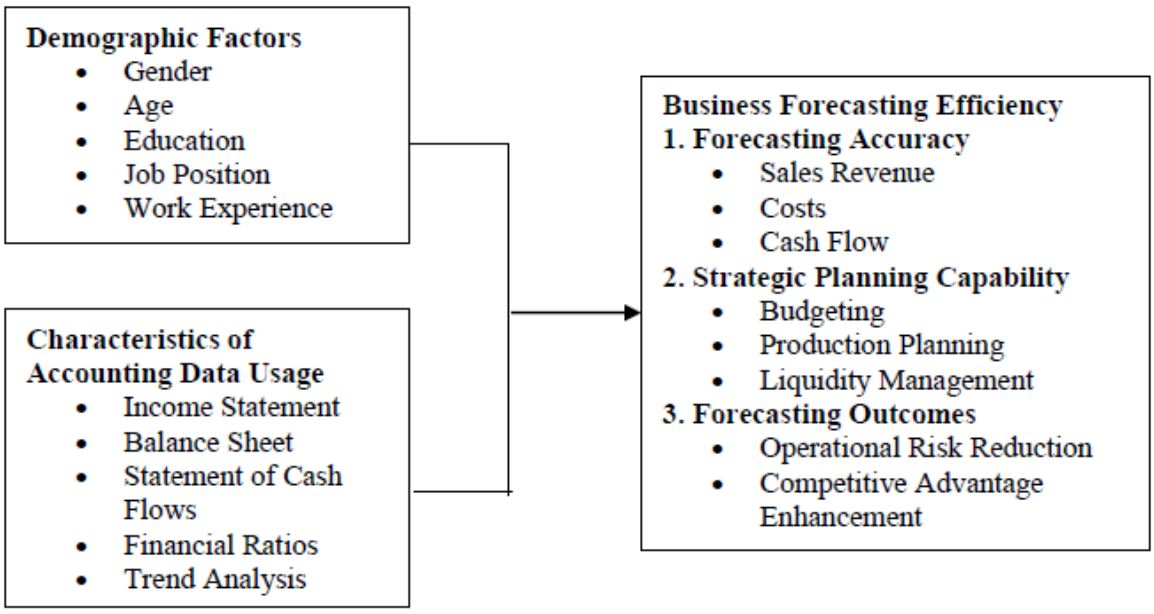
1. To utilize income statement data, including sales trends, costs, liquidity, liabilities, andprofitability, to enhance operational efficiency, inform investment expansion decisions, and manage financing, as well as to project future financial performance.

2. To serve as supportive data for the formulation of government policies aimed at promoting and developing Small and Medium Enterprises (SMEs).

3. To improve the survival rate of SMEs and mitigate the risk of business failure.

4. To strengthen the foundation of the grassroots economy and enhance overall economic resilience.

Conceptual Framework



Research Methodology

This study employs a quantitative research design. The development of the conceptual framework was initially conducted through documentary research to

examine the utilization of various types of financial statements and financial statement analysis for effective business forecasting among small and medium-sized enterprise (SME) entrepreneurs in the Nong Khaem District. The researcher synthesized relevant concepts and theories from extensive literature reviews, which served as the foundation for developing the research instruments used for data collection in this study.

Population and Sample

The target population for this study consists of executives and accounting supervisors within small and medium-sized enterprises (SMEs) registered in the Bangkok Metropolitan Area. The scope includes enterprises established between 2016 and 2024 that maintain active status. Given that the exact population size is unknown, the sample size was determined using W.G. Cochran's formula for an unknown population. The calculation was based on a 95% confidence level with a 5% margin of error. The resulting minimum required sample size was 384 participants to ensure a proportionate estimation with a maximum error of 5% at the specified confidence level. To facilitate data evaluation and analysis, the researcher collected data from a total sample of 400 respondents, which exceeds the minimum requirement of 384 and thus satisfies the specified statistical criteria.

Research Instruments

The primary tool for data collection in this study is a structured questionnaire. The variables within the questionnaire were derived and synthesized from an analysis of relevant theories, literature, articles, and previous research. The instrument is divided into three distinct sections as follows:

Section 1: General information and demographic profile of the respondents.

Section 2: Information regarding the utilization of accounting data, specifically financial statements (Income Statement, Balance Sheet, and Statement of Cash Flows), and financial analysis methods (Trend Analysis and Financial Ratio Analysis) for business forecasting among SMEs in the Nong Khaem District.

Section 3: Information regarding business forecasting efficiency in various dimensions, including accuracy, strategic planning, and practical forecasting applications for SMEs in the Nong Khaem District.

Quality Control of the Research Instrument

The researcher conducted quality assessments of the questionnaire through two primary tests: Content Validity and Reliability.

Content Validity: The questionnaire was evaluated by three academic experts. Following their recommendations, necessary revisions were made to the items. The resulting Index of Item-Objective Congruence (IOC) ranged between 0.67 and 1.00, confirming that the content is valid and suitable for data collection.

Reliability: For Section 2, after verifying content validity, a pilot test was conducted with 30 respondents in Nakhon Pathom Province. The analysis yielded a Cronbach's Alpha coefficient of 0.966, indicating a high level of internal consistency. This demonstrates that the questionnaire is highly reliable and appropriate for administration to the actual sample group.

Data Collection Procedures

For the quantitative data collection, the researcher distributed the questionnaires through two primary channels: an electronic format via Google Forms and manual distribution. The questionnaires were administered directly to small and medium-sized enterprises (SMEs) within the Nong Khaem Entrepreneurs Club. The sampling process employed a non-probability sampling technique, specifically utilizing convenience sampling for data acquisition.

Statistical Data Analysis

Once the data collection process was completed, the data were processed and analyzed. The statistical analysis is divided into three primary sections as follows:

Questionnaire Section 1

Demographic Profile of Respondents The researcher employed descriptive statistics to summarize the general information of the respondents. The analysis includes the calculation of frequency and percentage distributions.

Questionnaire Section 2 and Section 3

Descriptive Statistics: To describe the utilization of accounting information for business forecasting among small and medium-sized enterprises (SMEs) in the Nong Khaem District by analyzing the fundamental statistics of both independent and dependent variables. These statistical measures include the arithmetic mean and

standard deviation (Standard Deviation), utilizing a 5-point Likert scale which consists of five levels: Most Important, Very Important, Moderately Important, Slightly Important, and Least Important.

Data Interpretation Criteria: The researcher will utilize the calculated mean scores and interpret the results based on probability-based principles (Saryos & Saryos, 1995, p. 100) and the conceptual framework of Best (1977, as cited in Somprayoon & Somprayoon, 2003, p. 68). The criteria for interpreting the mean scores are as follows:

Mean Range	Interpretation
4.21-5.00	Indicates the highest level of importance
3.41-4.20	Indicates a high level of importance
2.61-3.40	Indicates a moderate level of importance
1.81-2.60	Indicates a low level of importance
1.00-1.80	Indicates the lowest level of importance

Research Results

Table 1 shows the personal characteristics of the respondents.

(n=400)

Variables		Frequency (n)	Percentage (%)
Gender	Male	243	60.8
	Female	157	39.2
	Total	400	100.0
Age	Under 30 years	64	16
	31 – 40 years	140	35.0
	41 – 50 years	168	42.0
	51 years and above	28	7.0
	Total	400	100.0
Educational level	Below Bachelor's Degree	116	29.0
	Bachelor's Degree	240	60.0
	Master's Degree or Higher	44	11.0
	Total	400	100.0
Job Position	Business Owner	56	14.0
	Manager	52	13.0
	Supervisor	218	54.5
	Staff / Employee	74	18.5
	Total	400	100.0
Work Experience	Less than 5 years	108	27.0
	5 – 10 years	78	19.5
	11 – 20 years	168	42.0
	More than 20 years	46	11.5
	Total	400	100.0
Business Size	Small Enterprise (fewer than 50 employees)	145	36.2
	Medium Enterprise (51–200 employees)	255	63.8
	Total	400	100.0

According to Table 1, the majority of the respondents were male (60.8%). Most were aged between 41 and 50 years (42.0%), held a Bachelor's degree (60.0%), and occupied supervisor positions (54.5%). Regarding work experience, the largest group had between 11 and 20 years of experience (42.0%), and the majority worked in medium-sized businesses with 51–200 employees (63.8%).

Table 2 shows the basic statistics for the analysis of accounting information utilization for business forecasting. (n=400)

No.	Items	$\bar{X}$	S.D.	Interpretation	Rank
1	Historical revenue and expense data from the Income Statement are used to forecast future performance.	4.33	.921	Highest	1
2	Profit and loss trends from the Income Statement allow management to assess future business directions.	4.23	.942	Highest	7
3	Utilizing Income Statement data for forecasting helps reduce discrepancies in sales and cost planning.	4.29	.908	Highest	2
4	The business uses assets, liabilities, and equity data from the Balance Sheet to assess future financial stability.	4.14	.942	High	13
5	Asset and liability structure data from the Balance Sheet help management forecast liquidity and financial risks.	4.2	.909	High	9
6	Utilizing the Balance Sheet for forecasting supports decision-making regarding investments, loans, and business expansion.	4.18	.935	High	12
7	Cash flows from operating activities are used to forecast the business's future liquidity.	4.21	.885	Highest	8
8	Cash inflow and outflow data from the Statement of Cash Flows help predict debt-servicing ability and estimate upcoming expenses.	4.23	.863	Highest	6
9	Utilizing the Statement of Cash Flows for forecasting reduces liquidity risks and supports financial planning.	4.24	.873	Highest	5
10	Financial ratios are used to forecast the business's future financial status.	4.19	.914	High	10
11	Analyzing historical financial ratio trends enables the prediction of business risks and opportunities.	4.25	.867	Highest	3
12	Utilizing financial ratios for forecasting supports decision-making in financial planning and business strategies.	4.24	.888	Highest	4
13	Historical trends of revenue, costs, or profits from accounting data are used to forecast future performance.	4.13	.940	High	14
14	Analyzing changes in accounting data over continuous periods can predict the business's direction.	4.18	.890	High	11
15	Utilizing trend data for forecasting reduces uncertainty and supports strategic planning decisions.	4.11	.917	High	15
	Total	4.21	.909	Highest	

According to Table 2, the results indicate that the use of historical revenue and expense data from the Income Statement to forecast future performance was ranked first, with the highest level of agreement ($\overline{X}$ = 4.33, S.D. = 0.921). This was followed by

the utilization of Income Statement data for forecasting to reduce discrepancies in sales and cost planning, which also stood at the highest level ($\overline{X}$ = 4.29, S.D. = 0.908). Additionally, the analysis of historical financial ratio trends to predict business risks and opportunities was ranked third, also reaching the highest level ($\overline{X}$ = 4.25, S.D. = 0.867).

Table 3 shows the basic statistics for the analysis of business forecasting efficiency.

No.	Items	$\bar{x}$	S.D.	Interpretation	Rank
1	The business uses Income Statement and trend data to accurately forecast sales.	4.16	.960	High	7
2	The business uses Income Statement data to accurately forecast costs and expenses.	4.18	.898	High	5
3	The business uses operating cash flow data to accurately forecast future cash flows.	4.2	.873	High	3
4	The business utilizes accounting information to prepare budgets for advance planning.	4.15	.901	High	8
5	The business utilizes accounting information for production planning and forward-looking strategies.	4.19	.875	High	4
6	The business utilizes accounting information for liquidity management planning.	4.25	.841	Highest	1
7	The business utilizes accounting information for forecasting to reduce operational risks.	4.16	.936	High	6
8	The business utilizes accounting information to enhance competitive advantage.	4.21	.862	Highest	2
	Total	4.2	.874	High	

According to Table 3, the business utilizes accounting information for liquidity management planning at the highest level ($\overline{X}$ = 4.25, S.D. = 0.841). This is followed by the use of accounting information to enhance competitive advantage ($\overline{X}$ = 4.21, S.D. = 0.862). Ranked third is the utilization of operating cash flow data to accurately forecast the business's cash flows, which stands at a high level ($\overline{X}$ = 4.20, S.D. = 0.873).

Table 4 presents the results of Stepwise Multiple Regression Analysis investigating the factors of accounting information utilization and business forecasting efficiency.

Business Forecasting Performance	B	S.E.	t	Sig.
Constant	.218	.102	2.130	.034
Trend Analysis	.528	.061	8.593	.00
Financial Ratio Analysis	.261	.039	6.613	.00
Income Statement Data	.180	.029	6.107	.00
Balance Sheet Data	.099	.037	2.665	.00
Statement of Cash Flows Data	.088	.043	2.049	.041
R-Square = 0.804 | Adjusted R-Square = 0.802 | F = 323.547 | Sig. = 0.000*				

*Statistically significant at the 0.05 level

According to Table 4, the utilization and analysis of accounting information—including data from the Income Statement, Balance Sheet, and Statement of Cash Flows, as well as Trend Analysis and Financial Ratio Analysis among Small and Medium Enterprises (SMEs) in the Nong Khaem district—resulted in an Adjusted R Square of 0.802. This indicates that these factors can effectively explain 80.2% of the positive influence on business forecasting performance. The remaining 19.8% is attributed to other variables not included in this study. The regression equation can be formulated as follows:

Y = .218 + .528 (T) + .261 (Ra) + .180 (PL) + .099 (BS) + .088 (CF)

Where: Y = Business Forecasting Effectiveness

T = Trend Analysis

Ra = Financial Ratio Analysis

PL = Income Statement Data

BS = Balance Sheet Data

CF = Statement of Cash Flows Data

Trend Analysis (b = 0.528): A one-unit increase in Trend Analysis results in a 0.528 unit increase in business forecasting effectiveness.

Financial Ratio Analysis (b = 0.261): A one-unit increase in Financial Ratio Analysis results in a 0.261 unit increase in business forecasting effectiveness.

Income Statement Data (b = 0.180): A one-unit increase in the use of Income Statement data results in a 0.180 unit increase in business forecasting effectiveness.

Balance Sheet Data (b = 0.099): A one-unit increase in the use of Balance Sheet data results in a 0.099 unit increase in business forecasting effectiveness.

Statement of Cash Flows Data (b = 0.088): A one-unit increase in the use of Statement of Cash Flows data results in a 0.088 unit increase in business forecasting effectiveness.

Summary and Discussion

According to the Multiple Regression Analysis, the model yielded an Adjusted R-Square of 0.802. This indicates that the five independent variables—namely Trend Analysis (T), Financial Ratio Analysis (Ra), Income Statement Data (PL), Balance Sheet Data (BS), and Statement of Cash Flows Data (CF)—collectively explain 80.2% of the variance in accounting information utilization for business forecasting among Small and Medium Enterprises (SMEs) in the Nong Khaem district. This high percentage reflects that the model is appropriate and possesses significant explanatory power. The remaining 19.8% may be attributed to other factors not included in this study, such as entrepreneurial experience, economic conditions, or government support.

Trend Analysis

The study results indicate that Trend Analysis has the highest influence (β = .528) on business forecasting effectiveness. This reflects that evaluating historical changes in revenue, costs, and profits is a crucial tool for predicting the future. These findings are consistent with the concepts of K.R. Subramanyam, who explained that trend analysis enables managers to identify performance patterns and directions, which serve as the foundation for financial forecasting.

Furthermore, the results align with the research of William H. Beaver, which found that historical financial data possesses the predictive ability to forecast a firm's future performance and risks. Consequently, the fact that this variable holds the highest influence suggests that SME entrepreneurs prioritize analyzing long-term trends over examining financial figures at a single point in time.

Financial Ratio Analysis

Financial Ratio Analysis holds the second-highest influence (β = .261), demonstrating that evaluating liquidity, profitability, and capital structure significantly enhances business forecasting effectiveness. These findings are consistent with the work of Raymond F. Smith and Eugene F. Brigham, who stated that financial ratios are essential tools for analyzing a firm's financial position and trends. Furthermore, the results align with the classic study by Edward I. Altman, who developed the Z-Score model using financial ratios to predict business failure, confirming the power of financial ratios in forecasting the future. Consequently, this study's results support the notion that ratio analysis is a vital instrument for reducing uncertainty in decision-making processes.

Income Statement Analysis

Income Statement Data has a positive influence (β = .180), indicating that revenue and net income information serve as primary data for evaluating growth trends. These findings are consistent with the work of Ray Ball and Philip Brown, who found that accounting earnings are correlated with firm value and possess the ability to reflect economic information. Furthermore, the study aligns with the model proposed by James A. Ohlson, which presents a valuation framework using accounting earnings as a core component. This demonstrates that profit plays a crucial role in forecasting business performance.

Balance Sheet Analysis

The Balance Sheet has a lower positive influence (β = .099). This may be attributed to the fact that it provides point-in-time information, which primarily reflects the financial structure rather than trend movements. Nevertheless, these findings remain consistent with the Conceptual Framework for Financial Reporting by the International Accounting Standards Board (IASB), which states that the Statement of Financial Position assists in assessing a firm's financial position and solvency. Although it may not capture dynamic changes as effectively as Trend Analysis, it remains an essential component for understanding the overall financial health of the business.

Statement of Cash Flows Analysis

The Statement of Cash Flows has a positive but the lowest influence (β = .088). This may reflect that SME entrepreneurs still prioritize earnings information over

cash flow data. Nevertheless, research by Gary C. Biddle et al. found that cash flow information possesses the predictive ability to forecast future cash flows and serves as a vital supplement to earnings data. Therefore, it can be concluded that although SMEs may not yet extensively utilize this information, it is considered to have high predictive value from an academic perspective.

The findings of this study are consistent with the Qualitative Characteristics of Financial Information theory proposed by the Financial Accounting Standards Board, which states that information possessing relevance and faithful representation supports economic decision-making. In summary, the study results indicate that 'Data Analysis' exerts a greater influence than the mere use of 'Raw Data' alone. This aligns with previous research confirming that a systematic interpretation of accounting information enhances predictive value and reduces uncertainty in entrepreneurial decision-making.

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Metaverse in Education for AI-Enhanced Lifelong Learning and SDG Advancement in the Context of an Aging Society: A Systematic Review

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Abstract

The rapid advancement of immersive technologies and Artificial Intelligence (AI) has reshaped digital education and introduced new possibilities for lifelong learning in aging societies. This study presents a systematic review of research published between 2020 and 2026 examining the integration of AI within Metaverse-based educational environments. Guided by the PRISMA framework, 18 peer-reviewed studies were identified and synthesized to analyze emerging research trends, pedagogical applications, and alignment with the Sustainable Development Goals (SDGs). Findings indicate a shift from technological infrastructure integration toward pedagogically focused applications, including intelligent tutoring systems, adaptive learning models, generative AI, and immersive simulations. AI enhances personalized learning pathways, real-time feedback, and experiential skill development within interactive virtual environments, supporting flexibility, self-directed learning, and continuous reskilling. The review further demonstrates strong alignment with SDG4 (Quality Education), SDG9 (Industry, Innovation, and Infrastructure), and SDG10 (Reduced Inequalities), highlighting the structural role of AI-enhanced Metaverse systems in promoting inclusive and sustainable educational ecosystems. Within the context of an aging society, immersive AI-driven environments show potential to mitigate mobility constraints, reduce social isolation, and foster cognitive engagement among older adults. AI-integrated Metaverse education represents an emerging paradigm capable of supporting inclusive, adaptive, and sustainable lifelong learning infrastructures in response to demographic transformation and global sustainability agendas.

Keywords: Metaverse in Education; Artificial Intelligence, Lifelong Learning, Aging Society

Introduction

The transition to the digital era has fundamentally transformed educational systems worldwide. Technological advancements in education have emerged extensively across diverse contexts, reshaping instructional practices and learning experiences into new forms that promote greater sustainability in digital learning environments. Furthermore, the COVID-19 pandemic significantly accelerated technological transformation in education, driving a rapid shift from traditional classroom-based instruction to online and distance learning (Illi & Elhassouny, 2025; Kaddoura & Al Husseiny, 2023). However, current two-dimensional online learning (2D e-learning) environments present several limitations, including decreased learner engagement, reduced motivation, and emotional isolation (Chua & Yu, 2024; X. Zhang et al., 2022). Advancements in communication and computing technologies have consequently led to the emergence of a new platform known as the "Metaverse," a three-dimensional virtual world that integrates the physical and digital realms, thereby overcoming spatial and temporal constraints (Chua & Yu, 2024; Samala et al., 2023).

The application of the Metaverse in education (Edu-Metaverse) represents a transformative shift in instructional design, utilizing Extended Reality (XR) technologies such as Virtual Reality (VR) and Augmented Reality (AR), in conjunction with the Internet of Everything (IoE), to create immersive and highly interactive learning environments (Illi & Elhassouny, 2025; Jagatheesaperumal et al., 2022; Tlili et al., 2022). Within these virtual spaces, learners and instructors can communicate and engage in collaborative activities through avatars. Educational Metaverse environments enable users to interact, communicate, and participate in simulated real-world experiences via avatars, effectively reducing barriers related to time and location (Illi & Elhassouny, 2025; X. Zhang et al., 2022).

At the same time, Artificial Intelligence (AI) has emerged as a significant driving force in reshaping educational practices. AI-driven systems facilitate adaptive learning pathways, intelligent tutoring systems, automated assessment, and predictive analytics through machine learning algorithms. These capabilities enhance learning efficiency and substantially transform digital learning experiences. The integration of the Metaverse with AI thus introduces a novel digital ecosystem (Lin et al., 2022; Odeh & Yousef, 2025; Yu,

2023) that extends beyond entertainment, serving instead as a platform that creates new opportunities for education and lifelong learning with greater flexibility and effectiveness (Chen et al., 2024; Saneinia et al., 2024; Yu, 2023).

Beyond general learner populations, this mode of learning demonstrates considerable potential for older adults, as it enables access to education, skills training, and social interaction without the need for long-distance travel, aligning with the concept of enhancing quality of life within home or community settings (Jagatheesaperumal et al., 2022; Owusu et al., 2023). Meanwhile, many countries are experiencing significant demographic shifts characterized by a steadily increasing proportion of older adults, marking the transition to aging societies. This social phenomenon, in which the elderly population continues to grow globally, has become increasingly prominent. The United Nations projects that one in six people worldwide will be aged 65 or older by 2050 (Mahmood & Dhakal, 2023). This demographic transformation not only challenges existing institutional systems and policy frameworks but also underscores the importance of promoting healthy aging and supporting older adults in maintaining quality lives within their homes or communities (Mahmood & Dhakal, 2023; Owusu et al., 2023).

However, older adults often face physical limitations, social isolation, and barriers to accessing new technologies, which may contribute to both physical and psychological decline. Therefore, promoting lifelong learning has becomes a critical strategy for sustaining cognitive capacity and social engagement among older populations (Lee et al., 2025). The integration of the Metaverse with AI represents an educational innovation that is closely aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4, which emphasizes inclusive and equitable quality education and the promotion of lifelong learning opportunities for all (Chen et al., 2024; Dragunova et al., 2023; Illi & Elhassouny, 2025). Furthermore, this developmental approach contributes to the advancement of innovation and digital infrastructure associated with SDG 9 (Industry, Innovation, and Infrastructure), while also supporting equitable access to digital education under SDG 10 (Reduced Inequalities), thereby fostering social inclusion within aging societies in the future.

From above, the application of the Metaverse within the context of aging populations emerges as an important mechanism for promoting lifelong learning and social participation. The Metaverse has the potential to eliminate physical barriers, enable older adults to connect, acquire new skills, and interact with others without the need for travel (Kaddoura & Al Husseiny, 2023; Lee et al., 2025). By overcoming geographical and physical constraints, it allows elderly individuals, vulnerable groups, and persons with physical limitations to access educational resources and engage in social interaction within virtual environments safely and equitably (Dragunova et al., 2023; Saneinia et al., 2024; Y. Zhang et al., 2022). Nevertheless, implementing the Metaverse among older adults presents specific challenges that must be carefully considered. Older individuals frequently encounter psychological barriers, including low self-confidence and perceptions of being too old to learn new technologies. Additional constraints include limited interest, financial barriers, and restricted access to digital technologies or devices (Lee et al., 2025). Consequently, technology design for older users must emphasize user-friendliness, provide step-by-step guidance, and incorporate family support as a key enabling factor in facilitating technology adoption (Lee et al., 2025; Sathyasundari et al., 2025).

Therefore, this study aims to conduct a systematic review of research published between 2020 and 2026 concerning the application of the Metaverse in education integrated with AI technologies. The objective is to analyze the role of these technologies in promoting lifelong learning and advancing the Sustainable Development Goals within the context of an aging society. Importantly, the analysis does not exclusively focus on elderly populations but instead utilizes demographic transformation as an interpretive framework for examining implications for lifelong learning. Specifically, this study addresses the following research questions.

Q1. What are the trends in educational research in the AI-integrated metaverse between 2020 to 2026?

Q2. How is AI being used in metaverse learning environments to promote lifelong learning?

Q3. How do AI-enhanced education systems in a metaverse contribute to achieving the SDGs?

Q4. What implications do these findings hold for learning in the context of an aging society?

By answering these questions, this systematic review aims to provide a comprehensive understanding of the evolving intersection between Metaverse technologies, AI-driven educational innovation, lifelong learning, and sustainable development. Ultimately, the study contributes to ongoing discussions on how emerging digital ecosystems can support inclusive and resilient learning infrastructures capable of responding to the challenges and opportunities presented by aging societies worldwide.

Methodology

Metaverse

The metaverse can be conceptualized as the integration of physical and digital realities into a unified virtual ecosystem, forming a global virtual community. Through the integration of Augmented Reality (AR) and Virtual Reality (VR) technologies, it enables the fusion of physical environments with immersive digital layers, creating seamless and interactive experiences. Supported by digital infrastructures such as the Internet, smart devices, software platforms, and networked applications, the metaverse represents a transformative technological paradigm with significant implications for the future of human interaction and digital engagement.

At present, the development of the metaverse is characterized by strategic competition among major technology corporations seeking to define its infrastructure, standards, and governance frameworks. Many organizations are investing in proprietary hardware and software ecosystems designed to attract users and establish control over platform access. This competitive landscape is further shaped by contrasting philosophies, particularly the tension between closed, commercially controlled systems and open, privacy-oriented architectures. As these competing visions evolve, the metaverse emerges not only as a technological innovation but also as a contested domain shaped by economic, ethical, and ideological considerations.

Importantly, the influence of the metaverse extends to various sectors, including education. Its immersive and interactive capabilities suggest strong potential to redefine digital learning environments, positioning it as a significant force in the evolution

of e-learning systems (Mystakidis, 2022). Consequently, the metaverse has become a central topic in contemporary discussions on technological advancement and digital transformation. From a conceptual perspective, the metaverse can be categorized into four primary types: Augmentation, Lifelogging, Mirror Worlds, and Virtual Worlds, as illustrated in Figure 1.

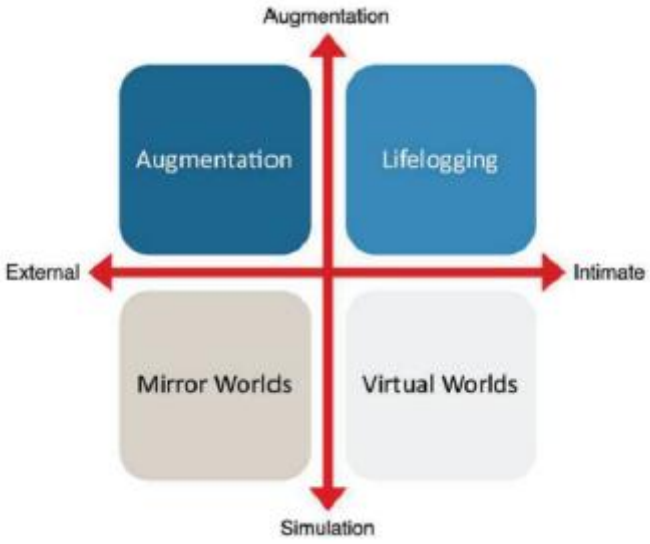


Figure 1 The Types of Metaverse (Suryodiningrat et al., 2022)

- Augmentation Metaverse refers to environments where digital information is layered onto the physical world to enhance users' perception and interaction. Utilizing technologies such as AR, this form enriches real-world experiences by integrating virtual elements into immediate surroundings.
- Lifelogging Metaverse involves the systematic and continuous documentation of individuals' daily lives. Through digital tracking and data recording technologies, personal activities, interactions, and environmental contexts are captured and stored for analysis or reflection.
- Mirror Worlds Metaverse represents digital replicas of real-world environments. These virtual environments function as digital twins, enabling users to explore and interact with simulations that closely resemble physical locations.
- The Virtual Worlds Metaverse consists of fully immersive and entirely computer-generated environments. Accessed primarily through VR technologies, these

spaces allow users to engage in social interaction, gaming, creative expression, and other digital activities within synthetic yet highly interactive landscapes.

PRISMA

This study adopts a systematic review methodology to address the research questions through a transparent, structured, and reproducible process. The review is guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework ('Gough et al., 2017; Page et al., 2021) which provides standardized procedures for identifying, screening, and synthesizing relevant studies. Following the application of predefined inclusion and exclusion criteria, selected publications were carefully examined to extract key findings. These findings were subsequently synthesized to generate evidence-based insights that directly respond to the research objectives.

The scope of this review encompasses scholarly works examining the application of the Metaverse in educational contexts in combination with Artificial Intelligence (AI). Particular emphasis is placed on the integration of Metaverse technologies with AI as an emerging educational innovation aligned with the United Nations Sustainable Development Goals (SDGs) and the broader societal transition toward an aging population. Only peer-reviewed articles published between 2020 and 2026 were considered. The detailed inclusion and exclusion criteria applied during the selection process are presented in Table 1.

Table1. Inclusion and Exclusion Criteria

Inclusion	Exclusion
Published between 2020-2026	Published before 2020
English language publication	Not in English
Doc. Type: Journal or Conference paper	Other Doc. Type (e.g. books)
Use of metaverse in education artificial intelligence	Not metaverse Not artificial intelligence
Focus on integration of metaverse and artificial intelligence, lifelong learning	Not integration
Can access / Open access	Can not access

To ensure comprehensive coverage of relevant literature, a systematic search strategy was developed using major academic databases, including Scopus, IEEE Xplore, and ScienceDirect. Frequently occurring keywords within related studies were analyzed to optimize search precision and recall (GALVEZ, 2018). Core search terms included "metaverse in education," "artificial intelligence (AI)," and "lifelong learning." Boolean operators (AND, OR, NOT) were strategically employed to refine and broaden the search results, thereby enhancing the rigor and completeness of the literature identification process.

Query Statement

TITLE-ABS-KEY ("metaverse") AND TITLE-ABS-KEY ("education") AND TITLE-ABS-KEY ("artificial intelligence") AND TITLE-ABS-KEY ("lifelong learning") AND PUBYEAR >= 2020 AND PUBYEAR <= 2026 AND (LIMIT-TO (LANGUAGE , "English"))

Result

The studies identified through the search were screened based on predefined criteria. This screening process was visualized through a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Flow Diagram, detailing each step and illustrating the number of studies excluded at each stage. Follow this, Identification, Screening, Eligibility and Included (Page et al., 2021).

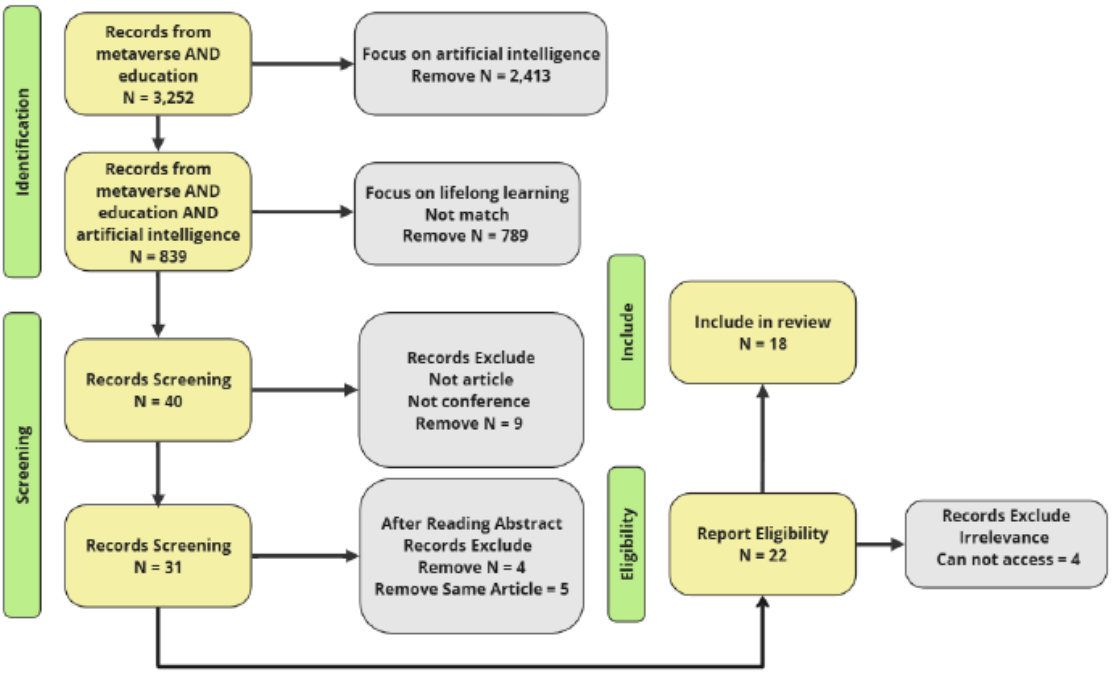


Figure 2 PRISMA Diagram

Based on the defined search strategy and the identification of core keywords related to metaverse, education, artificial intelligence (AI), and lifelong learning, with a publication timeframe limited to 2020–2026, a total of 18 relevant articles were initially retrieved. Following the application of the PRISMA screening and eligibility procedures, all 18 articles met the predefined inclusion criteria and were subsequently retained for final analysis.

The characteristics of the selected studies, organized according to the primary research questions, are summarized in Table 2. The table provides detailed information on each study, including the authors, year of publication, subject area, and the specific applications or roles of AI within the educational metaverse context.

Table2. Main data of the selected articles

No.	Authors	Year	Role of AI	Subject Area
(1)	(Abd El-Sattar, 2025)	2025	Intelligent NPCs Digital Twin	Special Education Immersive Technologies Metaverse
(2)	(Lampropoulos, 2025)	2025	Intelligent Tutoring Systems - ITS	Education
(3)	(Sathyasundari et al., 2025)	2025	Personalized learning	Education Management Ethics
(4)	(Suganya et al., 2025)	2025	Generative AI Adaptive Learning	Education
(5)	(Chen et al., 2024)	2024	Generative AI Natural Language Processing - NLP	Physical Education Metaverse
(6)	(Joshi et al., 2024)	2024	Tutoring Agents Adaptive Learning Explainable AI	Education Lifelong Learning
(7)	(Saneinia et al., 2024)	2024	AI with 5G network technology	Education Lifelong Learning Metaverse
(8)	(AlGerafi et al., 2023)	2023	Intelligently simulated environments of real-time interaction.	STEM Education Virtual Reality
(9)	(Dragunova et al., 2023)	2023	Adaptive Learning Chat Bot	Education Digital Technology
(10)	(Eppler & Spletter, 2023)	2023	Visual Learning Analytics	Education Knowledge Visualization
(11)	(Kruachottiku et al., 2023)	2023	AI-driven systems	Education Open Innovation Metaverse
(12)	(Phutela & Grover, 2023)	2023	AI is integrated with immersive technologies. AI supports instructional design processes.	Education Metaverse MOOCs
(13)	(Sa Don et al., 2023)	2023	AI contributes to the synthesis and dynamic generation of immersive environments.	Education Metaverse Serious games
(14)	(Yu, 2023)	2023	Tutoring Agents Intelligent Software Agents Reinforcement Learning	Education Immersive Learning AI
(15)	(Fu & Pan, 2022)	2022	AI integrated with other intelligent technologies	Education Metaverse
(16)	(Lin et al., 2022)	2022	Personal learning agent	Education Metaverse
(17)	(Wang et al., 2022)	2022	Intelligent Teaching Assistants Personalized learning	Open Education
(18)	(Y. Zhang et al., 2022)	2022	Deep learning	Education Metaverse

Beyond identifying emerging research trends in the integration of the Metaverse and AI, this study also seeks to examine the specific roles and applications of metaverse within AI-based research contexts. Investigates how AI is operationalized within immersive metaverse environments and how such integration contributes to the advancement of lifelong learning. These synthesized findings highlight the functional purposes, pedagogical strategies, and technological roles associated with AI-enhanced metaverse applications in education. A structured summary of these core issues is presented in Table 3.

Table3. AI-based use in Metaverse objectives.

Objective	AI-based	Description	Count
Intelligent Tutoring	Personalized learning Adaptive Learning Tutoring Agents Chat Bot	AI has been developed as an intelligent software agent or virtual tutor capable of analyzing learner behaviors and dynamically adapting its responses in real time. Functioning as an autonomous instructional intermediary.	10
Intelligent Learning Space	Intelligent Agent Generative AI Deep learning NLP	Environment is designed to support self-directed learning behaviors, with AI serving as a foundational support mechanism and generation of instructional materials and the deployment of interactive.	6
Sustainable ecosystem	AI-driven systems Deep learning	AI and big data analytics constitute foundational technologies underpinning intelligent simulation and immersive deep learning experiences within the Metaverse. This robust technological and socio-digital infrastructure provides essential support for the development of a sustainable ecosystem.	5
Simulations	Intelligent NPCs Digital Twin Machine Learning	AI is integrated with Metaverse technologies to establish interactive three dimensional learning environments and real-life simulations that enable learners to practice skills within safe and controlled settings.	4
Engagement	Intelligent NPCs Generative AI Chat Bot	AI are leveraged to develop interactive platforms designed to address the issue of learner disengagement in online course environments. AI create digital assistants, conversational chatbots, and adaptive learning systems that dynamically adjust content and instructional strategies based on learner needs.	3

The integration of Metaverse infrastructures with Artificial Intelligence (AI) represents a strategic educational innovation aligned with the United Nations Sustainable Development Goals (SDGs). It directly supports SDG4 by promoting inclusive, high-quality, and lifelong learning opportunities through immersive and adaptive digital environments. Simultaneously, the advancement of intelligent immersive infrastructures reflects SDG 9 (Industry, Innovation, and Infrastructure) by fostering innovation-driven knowledge societies, while equitable access to digitally mediated education aligns with SDG 10(Reduced Inequalities), emphasizing inclusive design in response to demographic aging and social vulnerability. A summary of each SDGs issues is presented in Table 4.

SDG	Achieve of SDG	Count
SDG4	• The Edu-Metaverse holds strong potential to reduce educational disparities between urban and rural communities, ensuring equitable access to high-quality learning opportunities . • By overcoming constraints related to time, location, and cost, immersive virtual environments promote inclusive and equitable education, particularly benefiting learners with special needs and socioeconomically disadvantaged groups. • The integration of Education 4.0 and Classroom 4.0 frameworks fosters adaptive, technology-driven learning models that support lifelong learning. • The implementation of Metaverse-based immersive learning modules reduces dependence on physical infrastructure, printed materials, and travel, thereby lowering carbon footprints and contributing to sustainable education. • Generative AI integrated with the Metaverse enables the provision of accessible, on-demand learning resources, helping bridge educational gaps in underserved and remote areas.	16
SDG9	• Strategic partnerships with private-sector organizations support the co-development of advanced Metaverse infrastructures and the establishment of national standards based on high-level technological foundations. • Industry–education collaboration promotes co-innovation, enabling virtual internships and practice-oriented training modules aligned with real-world workforce demands. • The deployment of advanced technological infrastructure such as IoT-enabled smart classrooms and high-performance computing systems and strengthens the digital education ecosystem.	4
SDG10	• Addressing digital equity within the Metaverse requires supportive policies and infrastructure subsidies to mitigate socio-digital inequalities, particularly between urban and rural regions. • Immersive educational innovations within the Metaverse provide safe virtual environments for individuals with autism to develop essential daily living skills through interactive simulation-based learning.	3

Discussion

Q1. What are the trends in educational research in the AI-integrated metaverse between 2020 and 2026?

The findings indicate a clear acceleration of research activity from 2022 onward, with a notable concentration of studies published between 2023 and 2025. This temporal clustering suggests that AI-integrated Metaverse research has shifted from conceptual exploration to applied experimentation within a relatively short time frame.

1. Conceptual to Functional AI Integration: Early studies (2022) primarily emphasized AI integration with immersive platforms at a structural level, focusing on system integration and intelligent technologies in Metaverse environments. However, by 2023–2025, research increasingly examined functional roles of AI, including.

- Intelligent Tutoring Systems (ITS)

- Tutoring agents and personal learning agents
- Chatbots and conversational agents
- Generative AI for dynamic content creation
- Deep learning and reinforcement learning applications.

2. Personalized and Adaptive Systems: Across the dataset, the most recurrent AI role was intelligent tutoring and adaptive learning systems. This dominance suggests that personalization has become the central research priority in AI-Metaverse education. The trend such as a shift toward learner-centered instructional models, emphasis on real-time behavioral analytics and increasing reliance on AI as an autonomous instructional mediator.

3. Immersive Simulation and Digital Twins: A secondary but significant trend concerns AI-powered simulations, including intelligent NPCs and digital twin technologies. These applications extend beyond personalization toward experiential learning and skills rehearsal within safe, controlled virtual environments.

4. Sustainable Ecosystem: AI and big data as foundational technologies supporting sustainable educational ecosystems. This reflects a conceptual broadening of the field from instructional enhancement toward socio-digital ecosystem development.

Q2. How is AI being used in metaverse learning environments to promote lifelong learning?

The thematic synthesis reveals five primary AI-enabled objectives in Metaverse learning environments. These objectives collectively support lifelong learning through personalization, autonomy, adaptability, and sustained engagement.

1. Intelligent Tutoring: The most prevalent function of AI involves intelligent tutoring, adaptive learning systems, tutoring agents, and chatbots. These systems such as Adjust instructional difficulty, monitor learner behavior in real time and autonomous instructional intermediaries.

2. Intelligent Learning Spaces: These supporting self-directed learning. Identified AI as foundational in designing intelligent learning spaces, automatic generation of instructional materials, interactive simulations, conversational support, and self-directed exploration.

3. Sustainable Ecosystem: AI and big data as foundational infrastructure technologies. In lifelong learning systems, this infrastructure, data-driven improvement, long-term scalability, and cross-institutional integration.

4. Simulation-Based: Digital twins, Intelligent NPCs, and Real-life scenario such immersive environments are essential for lifelong skill maintenance, reskilling, and upskilling particularly relevant in aging societies where experiential engagement may enhance cognitive stimulation.

5. Engagement: AI-driven digital assistants and generative content dynamically adjust learning experiences to sustain motivation. Given that emotional isolation is a documented limitation of 2D e-learning, AI-enhanced immersive interaction may reduce disengagement especially important for socially isolated older adults.

Q3. How do AI-enhanced education systems in a metaverse contribute to achieving the SDGs?

The findings demonstrate alignment with three primary SDGs: SDG4, SDG9, and SDG10.

1. SDG4-Quality Education: The dominant emphasis on personalized learning and intelligent tutoring directly supports, inclusive and equitable education, adaptive instructional delivery and continuous lifelong learning opportunities.

2. SDG9-Innovation and Infrastructure: Research emphasizing AI-driven systems and 5G integration and development of these, advanced digital infrastructure, immersive learning platforms and digital innovation ecosystems.

3. SDG10-Reduced Inequalities: AI-integrated Metaverse platforms reduce multiple forms of inequality by these, removing geographical barriers, supporting adaptive access for vulnerable populations, and enabling safe digital participation.

Q4.What implications do these findings hold for learning in the context of an aging society?

The context of an aging society is closely intertwined with the concepts of lifelong learning and adult education. The reviewed literature highlights several significant implications of AI and Metaverse technologies for learning in later life.

1. These technologies enable seamless learning continuity beyond formal schooling, employment, and even retirement, allowing individuals to remain engaged in education throughout their lifespan. (Chen et al., 2024)

2. AI-driven systems support experiential and self-directed learning models, offering the flexibility and personalization particularly suited to older adults who prefer interest-based and autonomous learning pathways. (Chen et al., 2024; Wang et al., 2022)

3. Immersive virtual interaction technologies enhance accessibility for vulnerable populations and individuals with physical limitations groups in which older adults are often represented by allowing participation through virtual identities, thereby reducing educational inequality. (Y. Zhang et al., 2022)

4. Generative AI facilitates adaptive learning across all stages of life, functioning as a personalized assistant that delivers tailored learning pathways and content aligned with potentially slower learning paces in older adulthood. (Saneinia et al., 2024; Suganya et al., 2025)

5. The provision of immersive three-dimensional simulations reduces the need for physical travel, enabling safe, cost-effective, and accessible learning experiences. Compared to traditional environments, virtual spaces create more equitable opportunities for lifelong participation in education. (Sathyasundari et al., 2025; Yu, 2023)

Conclusion

This systematic review synthesized 18 peer-reviewed studies published between 2020 and 2026 that examined the integration of Artificial Intelligence (AI) into metaverse-based learning environments. The analysis provides a structured overview of emerging research trends in education, the alignment of AI-enhanced Metaverse systems with the Sustainable Development Goals (SDGs), and their implications for learning within the context of an aging society.

First, the findings reveal a clear evolution in research trajectories. Early studies primarily focused on integrating AI into the technological infrastructure of the metaverse. In contrast, more recent research emphasizes pedagogical applications, particularly intelligent tutoring systems, adaptive learning models, generative AI, and immersive simulations. This progression reflects a transition from technological experimentation

toward learner-centered educational systems capable of scaling sustainably across broader educational ecosystems.

Second, AI plays a pivotal role in advancing lifelong learning within Metaverse environments. Tools such as intelligent tutoring systems, adaptive learning agents, chatbots, and generative AI support personalized learning pathways and continuous skills development. AI-driven immersive simulations further enable learners to practice and refine competencies in safe and controlled virtual environments. These components collectively enhance flexibility, self-directed learning, and ongoing reskilling—core characteristics of lifelong learning in knowledge-based societies.

Third, the findings demonstrate strong alignment between AI-enhanced Metaverse education systems and the Sustainable Development Goals. SDG4 (Quality Education) is supported through inclusive, adaptive, and lifelong learning opportunities. The development of AI-driven digital infrastructures aligns with SDG9 (Industry, Innovation, and Infrastructure), while expanded access to geographically unconstrained and personalized learning environments contributes to SDG10 (Reduced Inequalities). Accordingly, AI-integrated Metaverse systems function as both structural and transformative mechanisms in advancing sustainable educational development.

Within the context of an aging society, the significance of these findings becomes particularly pronounced. AI-enhanced immersive learning environments can mitigate mobility limitations, reduce social isolation, and support cognitive engagement among older adults. Adaptive learning systems accommodate diverse individual capacities, while virtual spaces create learning opportunities without requiring physical travel. These characteristics position the Metaverse as a promising digital platform for active aging and lifelong participation in education.

However, effective implementation requires careful consideration of age-friendly design, equitable access to technology, supportive policy frameworks, and appropriate ethical governance. Without inclusive planning and responsible regulation, such technologies may risk reinforcing existing social inequalities rather than alleviating them.

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Influences of Fake News Type on Audiences' Trust in News Source, News Forwarding and Commenting: A Case Study of Sina Weibo

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Abstract

This paper investigates the impact of exposure to various types of fake news on Chinese audiences in terms of trust and behavioral reactions. According to Wardle and Derakhshan's (2017) seven types of fake news – 1) satire/parody; 2) false connection; 3) misleading content; 4) false context; 5) imposter content; 6) manipulated content and 7) fabricated content, a survey study involving 300 Chinese Weibo users aged 18-35 years old with self-administered questionnaire was carried out through online and social media. The hypothesized effect of exposure to fake news type on trust, as well as on forwarding, and commenting behavior was tested by Multiple Regression and Linear Regression Analysis. Findings have shown that fabricated and manipulated content has a strong negative effect on trust whereas trust in news source is positively associated with news forwarding but not commenting behavior. Beyond its practical contributions, this study offers managerial implications for government offices, news media, and practitioners along with influencers to avert the spread of fake news, and also serves to inform the public about the significance of digital media literacy, which creates a barrier against the adverse effects of fake news.

Keywords: Fake news exposure, Sina Weibo, trust in news source, forwarding, commenting

Background and Statement of the Problem

The proliferation of fake news within the social media has turned into one of the biggest global issues of information ecosystems. Following the 2016 presidential elections in the United States, researchers documented that fake news was viewed more than 30 million times on Facebook, which was faced with massive concerns of how it may have affected the opinion and democracy (Allcott and Gentzkow, 2017). Such a study of false news dissemination was conducted by Vosoughi, Roy, and Aral (2018) on

Twitter, involving more than 126,000 news stories, who showed that fake news spread much further, in a shorter time, and more widely than factual information, and that fake political news is highly viral. In 2017, the fake news phrase was declared the Word of the Year in Collins Dictionary because it shows the unprecedented scale of such an event in the digital era. The breakdown of the institutional safeguards against misinformation in the age of the Internet needs multidisciplinary study in order to understand the individual vulnerability and develop countermeasures (Lazer, Baum, Benkler, Berinsky, Greenhill, Menczer, and Zittrain, 2018).

Sina Weibo is the major microblogging platform in China that has more than 500 million monthly active users and presents unique challenges of fake news spread in the country. Contrasting the Western platforms, Weibo is the only site where interpersonal, group, and mass communication can be mixed, providing complex information streams where false information can be distributed in several directions at the same time. The 140-character format of the platform does not focus on verifying content, but on timeliness and, given that around 80 percent of platform users are younger than 30, most of the user base is especially vulnerable to information disorder. Research on multi-domain false news on Weibo has revealed that political misinformation has the strongest diffusion capacity, while daily-life topics generate higher volumes of posts (Guo, Ding, Yao, Liang, & Yu, 2022). The Chinese social media studies have revealed that young people tend to blindly follow the information that is posted by their friends, forming chain-like patterns of transmission which enhance false information within networks (Li & Zhang, 2018). This tendency of behavior complicates the work of platforms that must preserve the quality of information during the dynamic cycles of content sharing and the absence of proper fact-checking mechanisms.

Although previous literature has addressed the dimension of fake news detection and trends of annualization, the study was scanty to measure the difference in the impact of the various forms of fake news on the audience credibility in the Chinese scenario. Although researchers like Pennycook and Rand (2021) have been able to summarize an increasing literature on the psychology of fake news in Western settings, limited literature has been conducted on the investigation of type-specific effects in the Chinese social media landscape. It is a key gap since it is necessary to learn about type-

specific effects to drive platform governance policies that allocate content moderation resources to the most harmful types of misinformation, as well as to develop evidence-based interventions that account for the specifics of Chinese social media platforms like Sina Weibo. This study addresses this gap through research on the impact of seven types of fake news according to the typology of Wardle and Derakhshan (2017) and how it affects the user trust towards Sina Weibo and subsequent forwarding and commenting behavior. In particular, this paper relies on the Agenda Setting Theory, Source Credibility Theory, and Uses and Gratifications Theory to hypothesize that the types of fake news have had different levels of influence on platform trust and that platform trust, in its turn, has a different impact on forwarding and commenting behavior of the users.

Objective

The study aims to realize three research objectives based on the analysis of literature and applicable theories: (1) to reveal whether exposure to fake news have impact on the trust; (2) to examine whether trust in news source on Sina Weibo serves as a significant predictor of audiences' forwarding and commenting behaviors in response to fake news, thereby exploring the potential linkage between fake news exposure, trust, and behavioral outcomes; and (3) to determine whether fabricated content and manipulated content have stronger effect on the platform credibility than other types.

Expected Benefits

The results of the research are likely to offer a number of contributions in various fields. Theoretically, the present study would be useful in the communication field since it combines Agenda setting Theory, Source credibility Theory and Uses and Gratifications Theory to a single concept under the aim of analyzing how the different forms of fake news produce varied effects of platform trust in the Chinese social media setting, thereby introducing Western-centric misinformation research into a culturally specific virtual space and broadening the theoretical scope of the type-specific effects of fake news. To govern the platforms, first, the results can inform Weibo and other platforms on which types of fake news most likely to damage trust should be detected and labeled, and thus, the resources of content moderation can be optimized. Second,

the findings of the type-specific impacts on trust can guide the development of specific regulations and socialization campaigns that can be used by the government offices and policymakers in response to the most detrimental types of misinformation. Third, the results underscore the pivotal significance of open sourcing and verification activities to the practitioners and influencers of news media to ensure audience credibility. Fourth, as an educator or media literacy activist, the study offers empirical support to designing culturally-sensitive digital media literacy campaigns that explicitly train young Chinese social media consumers to be aware of different forms of fake news. Lastly, to the general audience, the research highlights the importance of critical analysis of the material of online news and the importance of digital media literacy as one of the barriers to the negative impact of fake news.

Conceptual Framework

Founded in 2009, Weibo is now the leading story-aggregating social media platform in China that boasts 511 million monthly active users. In contrast to the traditional media, which uphold editorial gatekeeping, Weibo allows any user to post content to the potential millions of followers. More than 75 percent of users peruse trending topics and hot search features to consume news on a regular basis. Engagement-focused algorithms used to make the platform might unintentionally promote sensationalism, regardless of its truthfulness, and rumor-debunking systems tend to be massively outpaced by viral rumors (Zeng, 2012). The structural vulnerability is consistent with the general findings that social media platforms have a special challenge of controlling the quality of information because of low barriers to content creation and prioritizing engagement at the expense of accuracy (Lazer et al., 2018). Song, Kwon, Lu, Fan, and Li (2021) examined COVID-19 rumor dissemination on Weibo and found that source credibility played a decisive role in whether users retransmitted rumors or corrections. When analyzing the reactions of users to misinformation, Tandoc, Lim and Ling (2020) reported that the majority of social media users merely disregard the presence of fake news posts on the platforms. Additionally, Del Vicario, Bessi, Zollo, Petroni, Scala, Caldarelli, Stanley, and Quattrociocchi (2016) demonstrated that online

misinformation tends to spread through homogeneous clusters of like-minded users, creating echo chambers that further entrench false beliefs.

Wardle and Derakhshan (2017) have come up with a detailed model of distinguishing misinformation (false content disseminated without malicious intent), disinformation (deliberately false content), and malinformation (true content disseminated to harm). They distinguished seven categories: (1) satire/parody, which refers to humorous or exaggerated content not intended to cause harm but with the potential to mislead; (2) false connection, where headlines, visuals, or captions do not accurately represent the accompanying content; (3) misleading content, involving the selective use of information to frame an issue or individual in a biased manner; (4) false context, in which genuine content is shared with false or inaccurate contextual information; (5) imposter content, where genuine sources are impersonated to lend credibility to fabricated claims; (6) manipulated content, in which genuine information or imagery is altered or distorted to deceive and (7) fabricated content, which is entirely false content designed to deceive and cause harm. This typology is complementary to the academic classification conducted by Tandoc, Lim, and Ling (2018), who defined fake news on two dimensions, one facticity and the other deception, and found six types of operations which are satire, parody, fabrication, manipulation, advertising and propaganda.

Especially the analysis of Sina Weibo by the typology applies to the fact that dissimilar types of content generate diverse vectors of different manifestations of fake news. It is demonstrated that fake and distorted information is especially bad and uses cognitive biases to provoke more emotional responses compared to other content (Zhang and Ghorbani, 2020). The authors Martel, Pennycook, and Rand (2020) supplied causal support of the idea that making people more emotionally dependent makes them more vulnerable to accepting fake news. These are deliberate types of deception which are more challenging to uncover in habitual consumption and cause dire reputational and social harm after being discovered to be untrue. Moreover, Gelfert (2018) described fake news as a deliberate display of false or misleading statements as a news, with the focus on the intentional creation of the design to mislead. Fake news on social media have to be understood in the context of content features and social realities that propagate misinformation and perceive it as legitimate as emphasized by

Shu, Sliva, Wang, Tang, and Liu (2017). Zhou and Zafarani (2020) conducted a thorough overview of the fake news theories and detection approaches and stated that the key problem is the interdependence between the content features and user psychology.

This paper combines three theories that go hand in hand. Firstly, the Agenda Setting Theory (McCombs & Shaw, 1972) indicates that mass media determines what people regard as important as selective coverage and focus on. Within the environment of fake news, repeated exposure to untrue information can influence the perceived significance of some issue in the audiences, and, at the same time, influence the perception of the reliability of media sources. Vargo and Guo (2017) affirmed that fake news can be an active participant in intermedia agenda-setting processes and proved that the fabricated content could shape what the rest of media ecosystem can talk about.

Secondly, the Source Credibility Theory (Hovland & Weiss, 1951) provides that the acceptance of the message will be based on the perceived trustworthiness and expertise of the source(s). If viewers learn about fake news falsity, platform credibility is reduced, especially false content that is intentionally created. Park, Fisher, Flew, and Dulleck (2020) built upon this knowledge and proved that the use of social media per se is a contributor to the decrease in news trust across the world, and the features of the platform significantly mediate the way people trust news.

Thirdly, the Uses and Gratifications Theory or UGT (Katz, Blumler, & Gurevitch, 1974) describes the use of the media as a goal-oriented behavior that pursues a particular gratification. Upon the erosion of information-seeking needs by fake news, the users can alter the trust and engagement behavior. According to Pennycook, McPhetres, Zhang, Lu, and Rand (2020), individuals post misinformation because they do not evaluate the accuracy of the information; therefore, they believe that the desire to experience gratification may override critical appraisal mechanisms. Altay, Hacquin, and Mercier (2022) further demonstrated that reputation concerns serve as a significant deterrent to sharing false news, suggesting that social motivations interact with gratification-seeking in complex ways.

Review of literature and relevant theories above leads to development of the conceptual framework of this study. The framework integrates Wardle and Derakhshan's (2017) seven-type fake news typology with three established communication theories --

Agenda Setting Theory, Source Credibility Theory, and UGT -- to examine how users' exposure to different types of fake news affects trust in Sina Weibo, and how trust in news source in turn influences their forwarding and commenting behaviors. The independent variables are exposure to the seven types of fake news exposure (satire/parody, false connection, misleading content, false context, imposter content, manipulated content, and fabricated content). The mediating variable is trust in Sina Weibo as a news source. The dependent variables are forwarding behavior and commenting behavior. Based on the conceptual framework shown in Figure 1, four research hypotheses are proposed as follow:

HP#1: Chinese audiences' exposure to different types of fake news on Sina Weibo influences their trust in Sina Weibo as news source.

HP#2: Chinese audiences' trust in Sina Weibo as news source influences their forwarding fake news.

HP#3: Chinese audiences' trust in Sina Weibo as news source influences their commenting on fake news.

HP#4: Among seven types of fake news, fabricated content and manipulated content have higher impact on Chinese audiences' trust in Sina Weibo as news source than do other types.

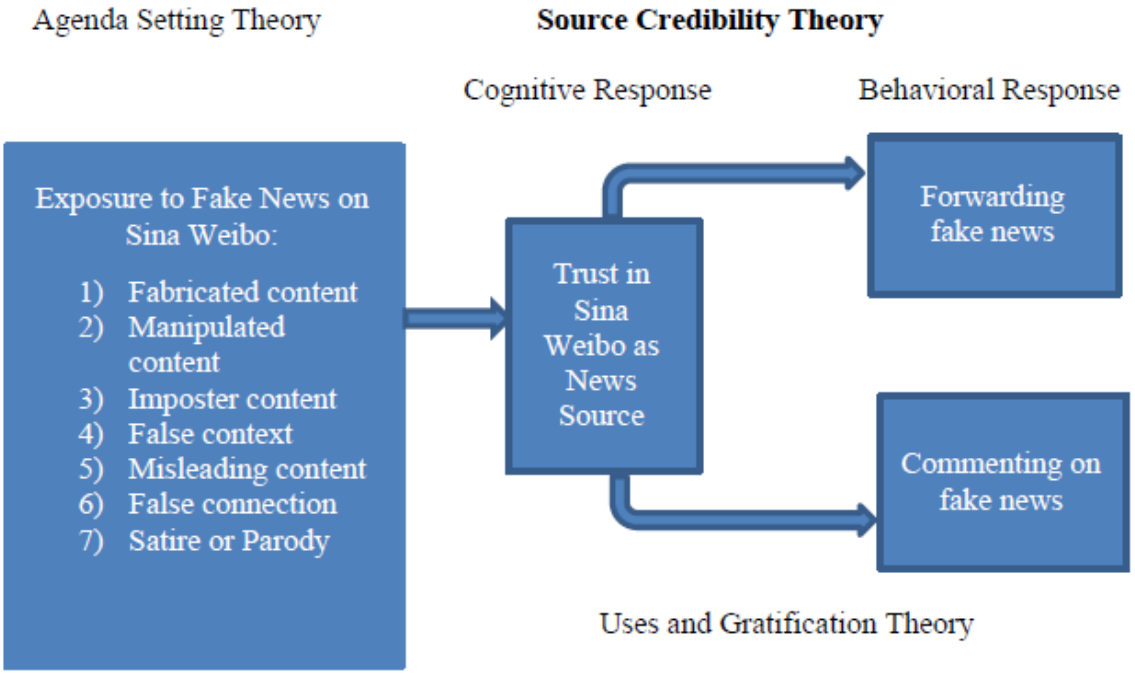


Figure 1. Conceptual Framework

Research Methodology

Online survey was adopted as a quantitative method to test the relationships of fake news exposure, trust and the behavioral outcomes. The target population was Chinese Weibo users aged 18-35, who also consume news content on the platform on a regular basis. The choice of this age group was due to the fact that users who are below 30 years old make up about 80% of the active users of Weibo. Online distribution channels were used to recruit 300 participants using stratified random sampling with G*Power analysis (α = .05, power = .80, medium effect size). A filter question facilitated that the participants had received news information during three months before data collection that they eventually found to be untrue or deceptive.

The self-administered questionnaire had 6 sections: (A) demographics, which included gender, age, education, income; (B) exposure to each of the seven fake news types measured using 5-point scales (1 = Never/ 2 = Seldom / 3 = Moderate/ 4 = Often / 5 = Always); (C) trust in Sina Weibo as a news source (3 items measuring attractiveness, trustworthiness, expertise, α = .87) and (D) forwarding behavior (3 items, α = .82) (E) commenting behavior (3 items, α = .79) and (F) engagement reasons basing on UGT dimensions. Attitudinal items were all Likert scales of 5 points. The criteria for interpreting the mean scores of each variable were established based on the equal interval method for a 5-point scale, where scores of 1.00 to 1.80 were classified as very low, 1.81 to 2.60 as low, 2.61 to 3.40 as moderate, 3.41 to 4.20 as high, and 4.21 to 5.00 as very high. The instrument was pretested with 30 respondents to establish initial reliability of the measurement scales, subjected to back-translation (English-Chinese-English) and pretested as well. Following the pretest, the questionnaire was administered to the full sample of 300 respondents for the main study. The collection of data was done using online and social media.

The processing and cleaning of data was then followed by the evaluation of multicollinearity (VIF < 5). The effect of the exposure of the audiences on the trust (HP#1 and HP#4) was subjected to Multiple Regression Analyses as compared to the impact of the trust on the forwarding by the audiences (HP#2) and the commenting by the audiences (HP#3) using the Linear Regression Analysis at a significance level of .05 or below. It is also worth mentioning that, although the conceptual framework implies trust

as a variable between fake news exposure and behavioral outcomes, the current study does not utilize a formal statistical mediation analysis e.g. the Sobel test or bootstrapping techniques suggested by Hayes (2018). Rather, the analytical method considers each of the hypothetical relationships an independent test using distinct regression models and then tests, sequentially, the effect of exposure to fake news on trust (HP#1), the effect of trust on forwarding (HP#2) and commenting (HP#3) as independent predictors. It is a sequential regression approach that enables the research to be able to gauge the direction and significance of each path without being able to claim any mediation. Also, it is important to mention that the general regression equation of the HP#1 exploits a composite measure of total exposure to fake news as a single predictor, but the type-specific analysis in the lower section of Table 4 introduces all seven types of fake news as simultaneous predictors in a model of multiple regression, which is why this difference in the model specification is expected and status of the positive overall coefficient is the cause of the negative individual coefficients of fabricated and manipulated content.

Research Results

In terms of demographic characteristics, 51% of respondents were female, 47.3% of them were male and 1.7% of them responded not to say. The largest age group was 20-29 years old (45.7%), followed by 30-35 years old (28.0%), and 18-19 years old (15.7%). Majority of the respondents hold bachelor's degrees (47.3%), followed by those with master's degree or higher (29.7%), and those with high-school diploma or lower (14.0%). As for frequency and percentage of time spent using media to read news daily, majority of them spent 30-59 minutes (32.7%) or less than 30 minutes (21.3%). Detail characteristics of the respondents are presented in Table 1.

Table 1. Frequency and Percentage of Respondents' Characteristics (N = 300)

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Female	153	51.0
	Male	142	47.3
	Prefer not to say	5	1.7
Age	18–19	47	15.7
	20–29	137	45.7
	30–35	84	28.0
	Other	32	10.7
Education	High school or below	42	14.0
	Bachelor's degree	142	47.3
	Master's or above	89	29.7
Time spent on using media to read news daily	Rarely	17	5.6
	Several times a week	41	13.7
	Less than 30 minutes	64	21.3
	30-59 minutes	98	32.7

Respondents' exposure to fake news of all types is considered moderate level ($\bar{X}$ = 3.03, S.D. = 1.04). The means of misleading content ($\bar{X}$ = 3.41, S.D. = 1.05), and false context ($\bar{X}$ = 3.37, S.D. = 1.09) were found to be the highest, which implies that these types of content were the most common issues encountered by the respondents, whereas fabricated content ($\bar{X}$ = 2.53, S.D. = 1.22) and satire/parody ($\bar{X}$ = 2.64, S.D. = 1.08) represented relatively low, which implies that these types of content were the least common issues exposed by the respondents.

The means of trust in Sina Weibo as a source of news was moderate ($\bar{X}$ = 3.28, S.D. = 0.91), which indicated that the level of trust towards the usefulness of the platform as a news source was moderate. The average scores in forwarding behavior ($\bar{X}$ = 2.92, S.D. = 1.16) and commenting behavior ($\bar{X}$ = 2.88, S.D. = 1.21) were slightly lower, which means that active engagement with the content of fake news is not as prominent.

The Cronbach's Alpha coefficients of all the measurement scales were ranging between.85 and.91 and this implies that all the constructs had sufficient measure reliability. It is worth mentioning that the reliability coefficients (Cronbach's Alpha) measured in Table 2 were calculated using the entire sample of 300 respondents obtained in the course of the main research, and not the pretest sample of 30 respondents. Although the pretest was performed to ensure that the instrument was initially adequately good, the reliability values provided in this context will be indicative of the psychometric performance of the scales over the entire sample, which will give a

more robust and generalizable measurement of the internal consistency. Table 2 of the descriptive statistics such as means and standard deviations are also calculated on the entire sample of 300 respondents. Table 2 is a summary of the descriptive statistics and reliability coefficients of each measured variable.

Table 2. Mean, Standard Deviation, and Reliability of Measured Variables

Variable	N	Mean	S.D.	No. of Items	Cronbach's Alpha
Fake News Exposure	300	3.03	1.04	7	.90
– Satire/Parody	300	2.64	1.08	1	-
– False Connection	300	3.02	1.14	1	-
– Misleading Content	300	3.41	1.05	1	-
– False Context	300	3.37	1.09	1	-
– Imposter Content	300	2.85	1.12	1	-
– Manipulated Content	300	2.71	1.18	1	-
– Fabricated Content	300	2.53	1.22	1	-
Trust in Sina Weibo	300	3.28	0.91	3	.85
Forwarding Behavior	300	2.92	1.16	3	.88
Commenting Behavior	300	2.88	1.21	3	.91

Further analysis of the trust levels across different fake news types revealed important variations. As shown in Table 3, the exposed to satire or parody, respondents reported the highest level of trust in Sina Weibo ($\bar{X}$ = 3.47, S.D. = 0.55), followed by false connection ($\bar{X}$ = 3.36, S.D. = 0.60). In contrast, exposure to fabricated content resulted in the lowest trust level ($\bar{X}$ = 2.41, S.D. = 0.72), closely followed by manipulated content ($\bar{X}$ = 2.53, S.D. = 0.69). These results suggest that the more deliberately deceptive forms of fake news are associated with greater erosion of platform trust.

Table 3. Mean and Standard Deviation of Trust in Sina Weibo Categorized by Fake News Type

Fake News Type	N	Mean	S.D.
Satire/Parody	300	3.47	0.55
False Connection	300	3.36	0.60
Misleading Content	300	3.24	0.58
False Context	300	3.12	0.61
Imposter Content	300	3.01	0.65
Manipulated Content	300	2.53	0.69
Fabricated Content	300	2.41	0.72

According to Table 4 that demonstrates the results of the detailed regression coefficients, according to Chinese audiences' exposure to various kinds of fake news on Sina Weibo has an impact on their trust in Sina Weibo as a news source, Multiple Regression Analysis results showed the support of HP#1 that exposure to fake news was a strong predictor of trust in Sina Weibo (R^2 = .397, $p < .001$). In this regard, the support of HP#1 was obtained (β = .34, $p < .001$). The overall positive value of the composite coefficient (β = .34) is to be viewed in terms of the aggregate measure of exposure that represents the overall frequency of exposure to fake news, as opposed to the trust-destroying impact of particular types of content. This positive correlation means that respondents who reported a higher overall exposure to fake news materials on Sina Weibo also reported a higher general awareness of the platform as a source of information, and this conceptual distinction is not similar to the type-specific effects of specific types of deceptive content that researchers are considering in the type-specific model below. The difference between this positive overall coefficient and the negative coefficients on fabricated and manipulated content in the type-specific model will indicate the difference in model specification since the overall model has one composite predictor, as compared to the type specific model in which the seven types are entered multitaskedly and the unique contribution of each type is obtained holding the rest constant.

When analyzing the impact of exposure to each type of fake news separately, the effects of fabricated content (β = -.31, $p < .001$) and manipulated content (β = -.28, $p < .001$) were significant and negative on trust. Interestingly, the effects of imposter content (β = -.05, $p > .05$), false context (β = -.07, $p > .05$), false connection (β = -.03, $p > .05$), misleading content (β = -.09, $p > .05$), and satire/parody (β = .02, $p > .05$) were insignificant.

Table 4. Multiple Regression Analysis Results on Predictors of Trust on Sina Weibo

Predictor	B	SE	Beta	t	P-Value	Result
Exposure to all types of fake news	0.55	0.04	.34	6.02	<.001***	Supported
Note. $R^2 = .397$, $F(1, 298) = 196.32$, $p < .001$ $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$						
Exposure to satire/parody	0.03	0.05	0.02	0.41	0.681	
Exposure to false connection	-0.07	0.05	-0.03	-0.62	0.537	
Exposure to misleading content	-0.06	0.06	-0.09	-1.67	0.096	
Exposure to false context	-0.10	0.05	-0.07	-1.32	0.187	
Exposure to imposter content	-0.12	0.05	-0.05	-0.91	0.364	
Exposure to manipulated content	-0.20	0.05	-0.28	-4.95	<.001***	Supported
Exposure to fabricated content	-0.22	0.05	-0.31	-5.52	<.001***	Supported

$R^2 = 0.39$, Adjusted $R^2 = 0.37$, $F(7, 292) = 26.20$, $p < 0.001$

*p < .05, **p < .01, ***p < .001

Table 5 presents the impact of trust in Sina Weibo on both behavioral outcomes, based on Linear Regression Analyses. In the case of HP#2: Chinese audiences' trust in Sina Weibo as news source influences their forwarding fake news, it was found that trust in Sina Weibo was supported that trust in Sina Weibo significantly predicted forwarding behavior ($R^2 = .072$, $\beta = .269$, $p < .001$) meaning that the more trust people have in the platform, the more news content, including fake news, they will forward. HP#2 was supported. This positive relationship, albeit weak, indicates that platform credibility facilitates content dissemination, consistent with the inattention-based sharing mechanism described by Pennycook and Rand (2021).

As for HP#3: Chinese audiences' trust in Sina Weibo as news source influences their commenting on fake news, was not supported as it did not significantly influence commenting behavior ($R^2 = .006$, $\beta = .076$, $p > .05$). HP#3 was thus not supported.

Table 5. Linear Regression Analysis on Trust as Predictor of Behavioral Outcomes

Behavioral Outcomes	R^2	B	Beta	t	P-Value	Result
Forwarding Behavior	.072	0.34	.269	4.81	<.001***	Supported
Commenting Behavior	.006	0.10	.076	1.31	.191	Not Supported

Note. *p < .05, **p < .01, ***p < .001.

In the case of HP#4: Among seven types of fake news, fabricated content and manipulated content have higher impact on Chinese audiences' trust in Sina Weibo as

news source than do other types, results of Regression Analysis confirmed that fabricated content (β = -.31, $p < .001$) and manipulated content (β = -.28, $p < .001$) had significantly stronger negative influences on trust than any other fake news type. However, as other five types of fake news had insignificant effect on trust, HP#4 was partially supported.

Summary of the Study

This online survey research examined the effects of seven types of fake news on audiences' trust in Sina Weibo and subsequent forwarding and commenting behaviors among 300 Chinese Weibo users aged 18–35 years old. Four research hypotheses were tested using Multiple Regression and Linear Regression Analyses. Results indicated that users' exposure to different fake news types significantly influenced their trust (HP#1 supported). Trust in Sina Weibo was found to positively predict forwarding behavior (HP#2 supported) but not commenting behavior (HP#3 not supported). HP#4 was partially supported, showing that fabricated content (β = -.31, $p < .001$) and manipulated content (β = -.28, $p < .001$) had stronger negative influences on trust compared to other types of fake news, whereas other types had no significant effect. Overall, the findings demonstrate that exposure to deliberately deceptive forms of fake news are most damaging to platform credibility, and that trust in news source facilitates content sharing, but does not drive commenting engagement.

The study also holds significant value to the misinformation research literature since it shows that the types of fake news have dissimilar levels of influence on platform trust in the Chinese social media setting, which has been underrepresented in the current literature primarily because of the influence of Western platforms. The combination of Agenda Setting Theory, the Source Credibility Theory, and Uses and Gratifications Theory enables the study to have a multi-theoretical approach, which adds to the comprehension of the functioning of fake news in culturally specific digital ecosystems. The observation that trust is a predictor of forwarding, but not commenting behavior is a particularly useful fact, as it indicates that there are two different ways of engagement, which are regulated by completely different psychological mechanisms. The informational gratifications and platform credibility judgment seem to drive

forwarding, whereas commenting is more directly related to the emotional arousal and social interaction motivations, which are independent of judgments based on trust, as proposed by the dual-process model presented by Pennycook and Rand (2021).

There are a few drawbacks in this study that must be mentioned. To begin with, the survey research design is cross-sectional, which does not allow drawing causal conclusions regarding the correlations between exposure to fake news, trust, and behavioral consequences. Second, the use of self-reported indicators on fake news exposure can be influenced by recall bias since respondents might not recall correctly the nature and frequency of fake news they came across. Third, the current study had sufficient statistical power due to the sample 300 Weibo users between the ages of 18 and 35, though further research should increase the sample size, which would improve the generalizability and acceptability of the research results, especially considering that the number of Weibo users in China is large and heterogeneous. Fourth, the trust-behavior models have relatively low values of R^2 (R^2 =.072 for forwarding, and R^2 =.006 for commenting), which implies that trust is not a major determinant of trust behavior outcome and other unmeasured factors, including emotional state, influence of the social network, and platform-specific characteristics are probably significant determinants of trust behavior outcome that should be investigated in further research.

Discussions

The results show that there are several theoretically and practically important patterns with regards to fake news and trust among Chinese social media. Such a high level of negative impact of fabricated and manipulated content on trust corresponds to the findings of previous research. Consistent with Tandoc and colleagues (2018), who argued that fabricated and manipulated content is widely perceived as more misleading because it mimics credible news forms, the current study confirmed that these two types of fake news significantly undermined trust in Sina Weibo more than other types. Zhang and Ghorbani (2020) further demonstrated that fabricated content on Chinese social media platforms exploits users' cognitive biases, making false information more likely to be initially accepted as true. The present study extends these findings by providing empirical evidence that exposure to fabricated content (β = -.31, $p < .001$) and

manipulated content (β = -.28, $p < .001$) produced the strongest negative effects on platform trust among all seven types.

It is also not surprising that satire and parody are rather unimportant in terms of trust, as it was also discovered by Tandoc and colleagues (2018) and Wardle and Derakhshan (2017), who both found that audiences tend to perceive satiric content as funny, as opposed to being misleading. This observation is also reflected by a study by Pennycook and Rand (2021) who claimed that a lack of critical thinking is what mainly motivates poor truth discernment and not the content itself, in that users can often be in the corrective position and determine that satire is non-serious.

The fairly low but meaningful correlation between trust and forwarding behavior ($R^2 = 0.072$) proves the paradox of the past literature: trust in a platform encourages sharing and does not guarantee checking of the content (Allcott and Gentzkow, 2017). The present observation is similar to Vosoughi, Roy, and Aral (2018) large-scale analysis, which established that the novelty of fake news, as opposed to intentionality to use it to deceive, was a key factor behind the sharing behavior. Similar words were used by Pennycook and colleagues (2020) who described this as inattention based sharing as the sharing among users is driven by the desire to share rather than consider the correctness of the content. Guess, Nagler, and Tucker (2019) also discovered that misinformation was infrequently shared on Facebook in general but was concentrated in several groups of demographic traits, which indicates that trust in the platform can selectively enhance forwarding in particular groups of users.

Particularly, it is interesting that the correlation between trust and commenting behaviour is insignificant. This finding contradicts the results described by Stieglitz and Dang-Xuan (2013), who indicated that the higher the engagement in comments, the more emotive content was being triggered. According to Martel and colleagues (2020), the use of emotion, instead of reason, facilitates the process of believing fake news, which can be the reason why commenting, as an emotion-sensitive behavior, does not depend on evaluations of trust. The conclusions made by Bakir and McStay (2018) were also based on the idea that fake news takes advantage of an economy of emotions, where user engagement is not based on the credibility of the news source but instead on affective reactions. The current research indicates that commenting behaviour in

Chinese Weibo scenario is more of a motivation to get emotional arousal and desire social interaction, as opposed to perceived credibility of the platform.

It is possible to draw the results in accordance with three developed theoretical frameworks. The Agenda setting theory (McCombs and Shaw, 1972) is useful in understanding how the cumulative exposure of fake news on Weibo is related to the perceived salience of the issue, and the perceived credibility of the site itself. Vargo and Guo (2017) have proven that fake news can be viewed as an active agent of the intermedia agenda-setting, and the present study has gone further to indicate that the most misleading forms of content have the highest determining power on how viewers will assess the credibility of the platform. The reason why fabricated and manipulated content had the largest negative impact on trust is well explained by the Source Credibility Theory (Hovland and Weiss, 1951) because in these instances of deliberate deception, the two elements of perceived trustworthiness and expertise are in the most direct conflict with one another. Appelman and Sundar (2016) have shown that message credibility is a unique construct than source credibility and that they are evaluated by viewers separately, which could be the reason why some forms of fake news harm platform trust more than others. The Uses and Gratifications Theory (Katz et al., 1974) can be used to explain the results of the conflict between the results of forwarding and commenting. The informational gratifications that determine forwarding and the non-significant ones that determine commenting indicate that trust is positively related to forwarding and does not impact commenting because commenting is driven by emotions and social interaction gratifications and does not rely on forms of credibility judgments (Stieglitz and Dang-Xuan, 2013). Altay, Hacquin, and Mercier (2022) discovered that reputational considerations are a major deterrent to the sharing of fake news, which is one possible reason why the trust-forwarding relationship is low.

Before doing this study, it was assumed that not every type of fake news would have the same impact on trust. It was predicted that intentional misrepresentative forms like fabricated and manipulated posts would cause the greatest harm to the platform credibility, and satire or parody would not have much influence. To some extent, the results supported these expectations. Nevertheless, the result of trust strongly predicting forwarding, and not commenting behaviour was partly surprising. The first hypothesis

assumed that trust would affect both types of interaction, but findings show a varying motivation driver can be used to comment. This surprising result complements the knowledge about the functioning of the audience attentions to fake news in terms of specific psychological processes, which are in line with the dual-process approach outlined by Pennycook and Rand (2021).

Recommendations

The present research not only gives managerial implications on government offices, news media, and practitioners, alongside the influencers to curb the spread of fake news, but also to the masses to realize the significance of digital media literacy that will protect against the increasing detrimental effects of fake news.

In the case of platform governance, Weibo will want to focus on the detection and labeling of fabricated and manipulated content since these forms of content have the most significant negative impact on user trust. Strategies to limit the dissemination of intentionally misleading information, by increasing the algorithmic transparency and formal liaisons with independent fact checking organizations, would help prevent the proliferation of the intentional misinformation, as Lazer and colleagues (2018) put, would be a vital step towards establishing new institutionalized protection against misinformation. Pennycook and colleagues (2020) demonstrated that simple accuracy prompts at the point of sharing can significantly reduce misinformation dissemination, a strategy that Weibo could implement to interrupt heuristic sharing patterns.

Media literacy education programs should be created to target the young Chinese users of social media and specifically learn to understand the types of fabricated and manipulated content. Leng, Zhai, Sun, Wu, Selzer, Strover, and Jiang (2022) found that COVID-19 misinformation on Weibo was driven by cultural and social entanglements, suggesting that media literacy programs should be culturally adapted to address the specific vulnerabilities of Chinese social media users. To news media practitioners and influencers, transparent sourcing and strict verification practices are the sole way to keep the audience trustful. As Aïmeur, Amri, and Brassard (2023) noted in their comprehensive review of social media misinformation, the convergence of fake news, disinformation, and malinformation requires multi-stakeholder responses that

combine technological, educational, and regulatory approaches. To conduct research in the future, cross-platform comparative research to include platforms like WeChat, TikTok, and similar platforms internationally would help us understand whether the type-trust patterns can be considered platform-specific or culturally generic. Causal inferences would be better supported by experimental methods involving exposure of the experimental participants to controlled fake news stimuli in natural real-time digital environments. Moreover, the fact that the level of R^2 in the trust-behavior regression models is relatively low (R^2 =.072 for forwarding, and R^2 =.006 for commenting) demonstrates that trust in news source is not the only factor that can explain the variance in audience engagement behavior. The future studies should thus include other predictor variables like the emotional arousal, perceived social influence, platform-specific algorithmic exposure and the individual media literacy level into the regression models to enhance the explanatory power and get better R^2 values. The application of Structural Equation Modeling or hierarchical regressions modeling that incorporate these other variables would give a better picture of the complex processes by which exposure to fake news is converted into behavioral results in social media.

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A Health Literacy Model for Healthy Eating, Emotional Health, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province

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Abstract

This research aimed to: 1) examine the current status of health literacy development in promoting eating behavior, emotional management, and exercise among Village Health Volunteers (VHVs) in Bang Yai District, Nonthaburi Province; 2) analyze factors influencing health-promoting behaviors in these three dimensions; and 3) propose a model for health literacy development to enhance health promotion practices among VHVs.

This study employed a descriptive research design. The population consisted of 210 Village Health Volunteers who attended the annual VHV meeting in 2024. The sample size was determined using Taro Yamane's formula, yielding 140 participants. Data were collected using a structured questionnaire comprising three parts: personal characteristics; management processes for health literacy development based on the PDCA cycle (Plan–Do–Check–Act) with 16 items; and health literacy behaviors in promoting eating, emotional health, and exercise based on the V-SHAPE framework (Access, Understand, Interact/Exchange, Decide, Change Behavior, Share/Empower) with 12 items. The instrument demonstrated content validity (IOC = 0.67–1.00) and high reliability (Cronbach's alpha = 0.95). Data were collected from January 1–31, 2025, with a response rate of 100 percent. Data were analyzed using descriptive statistics (percentage, mean, standard deviation) and inferential statistics including multiple regression analysis.

The findings revealed that the overall management process for health literacy development was at a moderate level ($\bar{x}$ = 3.21, S.D. = .52). Among the PDCA components, the "Act" dimension (continuous improvement) showed the highest mean score at a high level ($\bar{x}$ = 3.75, S.D. = .41), while the "Check" dimension ranked lowest but remained at a moderate level. Regarding health literacy behaviors based on the V-

SHAPE framework, the overall level was moderate ($\bar{x}$ = 2.54, S.D. = .63). The highest mean was found in the Access dimension, followed by Interact/Exchange, whereas Share/Empower had the lowest mean score.

Multiple regression analysis indicated that the "Check" (B = .58, Beta = .492, $p < .001$) and "Act" (B = .34, Beta = .224, p = .005) components significantly predicted health literacy behaviors. The model demonstrated a multiple correlation coefficient (R) of .65 and an adjusted R^2 of .42, indicating that management processes explained 42 percent of the variance in health literacy promotion behaviors. The predictive equation in raw score form was: $\hat{Y}$ = .59 + (.58 Check) + (.34 Act).

The results suggest that systematic monitoring and continuous improvement mechanisms are critical determinants in strengthening health literacy behaviors among VHVs. Therefore, an effective model for health literacy development should emphasize evaluation, reflective practice, and sustainable improvement processes to enhance eating behavior, emotional well-being, and exercise promotion at the community level.

Keywords: Health Literacy Model, PDCA Management Process, Village Health Volunteers, Eating Behavior, Emotional Health, Exercise Promotion

Background and Statement of the problem

Health promotion is a fundamental strategy of modern health systems aimed at empowering individuals to effectively control and sustainably improve their own health status. It encompasses essential dimensions of health behavior, including appropriate dietary practices, adequate physical activity, and balanced mental and emotional well-being. These three components constitute key health determinants that are directly associated with population health outcomes and quality of life. The World Health Organization and the Ministry of Public Health have emphasized that proper nutritional consumption, regular exercise, and appropriate emotional management are critical mechanisms for preventing non-communicable diseases (NCDs) and enhancing health well-being across the life course. In this regard, the Department of Health, Ministry of Public Health, has established strategic guidelines for promoting health behaviors through the development of health literacy, enabling individuals to access, understand,

analyze, evaluate, and appropriately apply health information within their specific contexts. This approach serves as a foundational framework for proactive community-based health system development (Department of Health, 2022).

However, the current health situation of the Thai population reflects persistent challenges in sustaining appropriate health-promoting behaviors. A substantial proportion of Thai people continue to engage in unhealthy dietary practices, including excessive consumption of sugar, fat, and sodium beyond recommended standards, insufficient levels of physical activity, and increasing exposure to stress and mental health problems. Data from the National Health Examination Survey (NHES) and reports from the Division of Non-Communicable Diseases, Department of Disease Control, indicate that more than 25 percent of the Thai population has insufficient physical activity levels and consumes fruits and vegetables below recommended guidelines. Furthermore, rising trends in stress and depressive symptoms have been observed. These findings reflect limitations in health literacy and in the behavioral management capacity of the population (Department of Disease Control, 2023).

The V-SHAPE Health Literacy Framework, developed by the Department of Health, Ministry of Public Health, represents a significant conceptual model for enhancing individuals' capacity to manage their own health effectively. The framework comprises essential processes including Access to health information, Understand, Interact, Decide, Change behavior, and Share. These processes are interconnected with the development of cognitive skills, social skills, and self-management competencies in a systematic manner. The integration of this framework with the PDCA management cycle (Plan–Do–Check–Act) facilitates systematic health promotion operations through structured planning, implementation, monitoring, evaluation, and continuous improvement. Such integration aligns with quality improvement approaches in area-based health management (Department of Health, 2021).

Village Health Volunteers (VHVs) constitute a crucial mechanism within Thailand's primary health care system, serving as a linkage between health service units and community members. Their roles include disseminating health information, facilitating behavioral modification, and promoting well-being at household and community levels on a continuous basis. Under the "Three Doctors Policy" and the

strengthening of the primary care system, VHVs play essential roles in health screening, nutritional counseling, promotion of physical activity, and mental health support within communities. The effectiveness of these roles depends largely on their level of health literacy and the presence of a structured management system that supports their work. The development of an appropriate health literacy enhancement model would therefore improve both efficiency and effectiveness of health promotion activities at the community level (Division of People's Health Support, 2022).

Simultaneously, the burden of non-communicable diseases in Thailand remains a significant public health concern. The prevalence of diabetes mellitus, hypertension, and obesity has shown a continuous upward trend. Ministry of Public Health data indicate increasing incidence rates of diabetes and hypertension annually, closely associated with inappropriate dietary behaviors, insufficient physical activity, and chronic stress. Overweight and obesity, including abdominal obesity, represent major metabolic risk factors for NCDs and have been steadily increasing among the Thai population. According to the Sixth National Health Examination Survey (2019–2020), 42.2 percent of Thai adults aged 15 years and older were classified as overweight or obese (BMI ≥ 25 kg/m²), with a notably higher prevalence among females. When considering abdominal obesity, defined by waist circumference (≥ 90 cm for males and ≥ 80 cm for females), more than half of Thai adults met the criteria, indicating excessive visceral fat accumulation associated with type 2 diabetes, hypertension, cardiovascular disease, and metabolic syndrome. These trends are strongly related to unhealthy behaviors, including high-energy food consumption, inadequate physical activity, and sedentary behavior, influenced by rapid lifestyle transitions in urban and semi-urban settings. Data from the Department of Health further reveal that abdominal obesity is increasing across all age groups, particularly among working-age adults and the elderly, contributing to long-term healthcare expenditures and diminished quality of life. Therefore, strengthening health literacy mechanisms to modify dietary habits, enhance physical activity, and improve emotional regulation represents a strategic approach to controlling and preventing obesity and abdominal obesity at the community level (Aekplakorn, 2021; Department of Health, 2022).

Nonthaburi Province, located within Health Region 4, represents a semi-urban area undergoing rapid social and lifestyle transformations, thereby increasing population vulnerability to non-communicable diseases. The prevalence of obesity and abdominal obesity in this province exceeds the national average, consistent with epidemiological patterns observed in urbanizing areas contiguous with Bangkok Metropolitan Region. Rapid demographic, economic, and lifestyle changes have shifted dietary patterns toward processed and high-calorie foods, high-fat and high-sodium diets, reduced occupational physical activity in service and industrial sectors, and increased sedentary behavior associated with digital technology use. These factors collectively contribute to an obesogenic and unhealthy food environment.

Given the significance of these public health challenges, investigating a health literacy development model to promote healthy eating, exercise, and emotional management among Village Health Volunteers in Bang Yai District, Nonthaburi Province, is critically important. Such a study enables the identification of current operational conditions, personal characteristics, and PDCA-based management processes influencing health literacy behaviors. The findings can inform the development of an effective, context-specific operational model that may serve as a prototype for sustainable community-based health promotion systems, ultimately supporting national goals for reducing non-communicable diseases and improving population quality of life in the long term.

Objective

1. To examine the current status of health literacy development in promoting healthy eating, physical activity, and emotional well-being among Village Health Volunteers in Bang Yai District, Nonthaburi Province.
2. To analyze factors influencing health-promoting behaviors related to dietary practices, emotional management, and physical activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province.
3. To propose a health literacy development model for promoting healthy eating, physical activity, and emotional well-being among Village Health Volunteers in Bang Yai District, Nonthaburi Province.

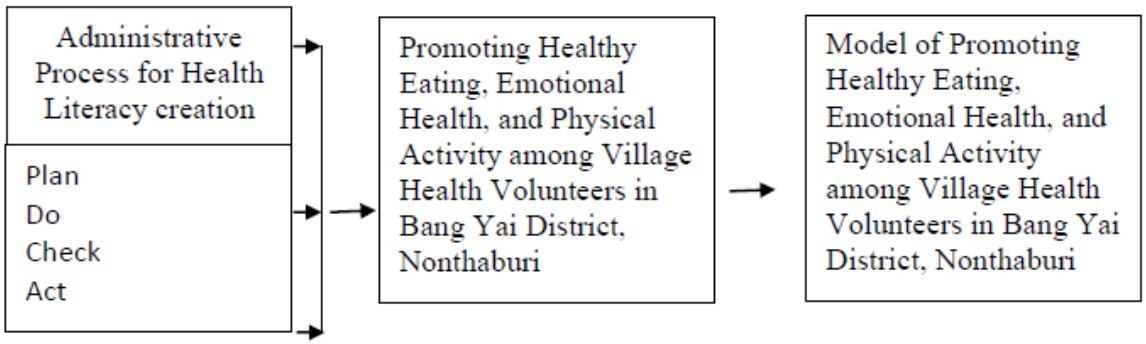
Expected benefits

1. Obtain empirical data regarding the current status of health literacy development in promoting healthy eating, physical activity, and emotional well-being among Village Health Volunteers in Bang Yai District, Nonthaburi Province.

2. determine the key predictive factors influencing health-promoting behaviors related to dietary practices, emotional management, and physical activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province.

3. develop a context-specific health literacy model for promoting healthy eating, physical activity, and emotional well-being among Village Health Volunteers in Bang Yai District, Nonthaburi Province.

Conceptual Framework



Research Methodology

This research entitled "A Health Literacy Development Model for Promoting Healthy Eating, Emotional Well-being, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province" employed a descriptive research design. Data were collected through a structured questionnaire. The research methodology is detailed as follows:

Population

The population consisted of 210 Village Health Volunteers in Bang Yai District, Nonthaburi Province, who attended the annual Village Health Volunteer meeting in 2024. The sample size was determined using Taro Yamane's formula, resulting in a sample of 140 participants. A simple random sampling technique was employed to select participants from the list of eligible VHVs attending the meeting. This method was

chosen to ensure that each individual had an equal chance of selection, thereby reducing selection bias and enhancing the representativeness of the sample.

The selected sample was considered representative of VHVs in the district, as participants were drawn from all sub-districts and shared similar roles and responsibilities within the primary healthcare system.

However, this study has some limitations. Since participants were recruited from those attending the annual meeting, VHVs who were absent may differ in characteristics such as motivation or health behaviors. Therefore, the generalizability of the findings to all VHVs in the district or other settings should be interpreted with caution.

Research Instrument

The research instrument was a structured questionnaire comprising three sections.

Part1collected demographic information of respondents. Part 2 assessed the current status of management processes for health literacy development in promoting healthy eating, emotional well-being, and physical activity among Village Health Volunteers. This section included 16 items covering the PDCA management cycle: planning, implementation, monitoring (checking), and improvement (acting).Part 3 assessed health literacy behaviors in promoting healthy eating, emotional well-being, and physical activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province, consisting of 12 items.

Instrument Validation and Reliability

Content validity was examined using the Index of Item-Objective Congruence (IOC), yielding values ranging from 0.67 to 1.00. Reliability analysis demonstrated a high internal consistency with a Cronbach's alpha coefficient of 0.95

Data Collection

Data were collected through questionnaire administration between January 1–31, 2025. A total of 140 completed questionnaires were returned, representing a 100 percent response rate.

Data Analysis

Data were analyzed using descriptive statistics, including percentage, mean, and standard deviation. Inferential statistics were employed, including multiple regression analysis.

Classification Criteria

The levels of management processes for health literacy development and health literacy behaviors were categorized into three levels: high, moderate, and low.

Research Results

The findings of this study are presented according to the research objectives as follows:

1. Personal Characteristics of the Respondents

The demographic characteristics of the Village Health Volunteers who participated as respondents can be described as follows: The majority of respondents were female (62.1%). Most were aged between 41–50 years (40.7%). Regarding work experience, 50.7% had more than 15 years of service as Village Health Volunteers.

2. Management Processes for Health Literacy Development in Promoting Healthy Eating, Emotional Well-being, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province

In this section, data were analyzed and presented regarding the management processes supporting health promotion and disease prevention in the areas of dietary practices, emotional well-being, and physical activity among Village Health Volunteers. The management processes were structured according to the PDCA cycle, including planning, implementation, monitoring (checking), and improvement (acting). The interpretation of management process levels was categorized into three levels: high, moderate, and low. Additionally, each component was ranked according to its mean score from highest to lowest performance level.

Table 1 shows the average standard deviation and the ranked of each management aspect and overall process for health literacy creation for Promoting Healthy Eating, Emotional Health, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi

Evaluation list	Evaluation			
	$\overline{X}$	S.D	Results	Ranked
1. Plan	3.28	0.57	Moderate	2
2. Do	3.24	0.59	Moderate	3
3. Check	3.13	0.53	Moderate	4
4. Act	3.75	0.41	high	1
5. Overall	3.21	0.52	Moderate	

Table 2 shows the average standard deviation and the ranked of each management items for health literacy creation for Promoting Healthy Eating, Emotional Health, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi

Evaluation list	Evaluation			
	$\overline{X}$	S.D	Results	Ranked
1. Plan				
Assessment of health problems and needs prior to activity implementation	3.42	0.67	Moderate	4
Situation analysis (strengths, weaknesses, opportunities, and threats) in implementation	2.90	0.75	Moderate	15
1. Plan				
Establishment of health objectives and operational plans	3.26	0.66	Moderate	8
Target group participation in planning health activities	3.53	0.76	High	3
2.Do				
Allocation of roles and responsibilities in implementation	3.22	0.83	Moderate	9
Provision of health education activities according to the established plan	3.30	0.60	Moderate	6
Utilization of appropriate learning media and methods for the target group	3.16	0.82	Moderate	12
Participants' engagement in hands-on practice for self-health management	3.29	0.57	Moderate	7
3.Check				
Monitoring implementation according to the specified timeline	3.33	0.58	Moderate	5
Ongoing evaluation during implementation	3.21	0.66	Moderate	10
Post-activity evaluation of health knowledge or behaviors	2.84	.66	Moderate	16
Joint reflection on operational outcomes between organizers and participants	3.11	0.60	Moderate	13
4.Act				
Summary meeting of operational outcomes	3.18	0.60	Moderate	11
Adjustment of activity formats based on evaluation results	3.06	0.87	Moderate	14
Expansion of health activities in the subsequent fiscal year	4.25	0.74	High	2
Development of sustainable health operational guidelines	4.52	0.63	High	1

3. Health-Promoting Behaviors Related to Healthy Eating, Emotional Well-being, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province

In this section, the researcher analyzed and presented the management processes supporting health promotion and disease prevention in the areas of dietary practices, emotional well-being, and physical activity among Village Health Volunteers. These processes were examined according to the V-SHAPE health literacy framework, comprising Access, Understand, Interact/Exchange, Decide, Change Behavior, and Share/Empower.

The interpretation of health literacy development levels was categorized into three levels: high, moderate, and low. Each component was ranked according to its mean score from highest to lowest performance level, as presented in Tables 3 and 4.

Table 3 shows the average standard deviation and the ranked of Promoting Healthy Eating, Emotional Health, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi

Evaluation list	Evaluation			
	$\overline{X}$	S.D	Results	Ranked
1. Access	2.65	0.61	Moderate	1
2. Understand	2.54	0.63	Moderate	3
3. Interact / Exchange	2.60	0.64	Moderate	2
4. Decide	2.53	0.65	Moderate	4
5. Change Behavior	2.51	0.63	Moderate	5
6. Share / Empower	2.47	0.62	Moderate	6
Overall	2.54	0.63	Moderate	

Table 4 shows the average standard deviation and the ranked of the items of Promoting Healthy Eating, Emotional Health, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi

Evaluation list	Evaluation			
	$\overline{X}$	S.D	Results	Ranked
1. Access				
Ability to obtain health information from reliable sources	2.51	0.68	Moderate	8
Adequate access to health information channels	2.66	0,61	Moderate	2
2. Understand				
Understanding health information received from activities/media	2.56	0.63	Moderate	5
Ability to correctly follow health recommendations	2.46	0.66	Moderate	10
3. Interact / Exchange				
Asking questions when health information is unclear	2.56	0.64	Moderate	4
Participation in exchanging health-related ideas within the group	2.69	0.46	Moderate	1
4. Decide				
Evaluating the credibility of health information before making decisions	2.53	0.65	Moderate	6
4. Decide				
Making appropriate health behavior decisions suitable for oneself	2.49	0.65	Moderate	9
5.Change Behavior				
Applying health knowledge consistently in daily life	2.58	0.49	Moderate	3
Ability to modify health risk behaviors	2.51	0.63	Moderate	7
6. Share / Empower				
Disseminating health knowledge to family or community members	2.45	0.63	Moderate	11
Confidence in serving as a health role model to encourage appropriate behavior change	2.43	0.63	Moderate	12

4. Factors Influencing Health-Promoting Behaviors Related to Healthy Eating, Emotional Well-being, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province

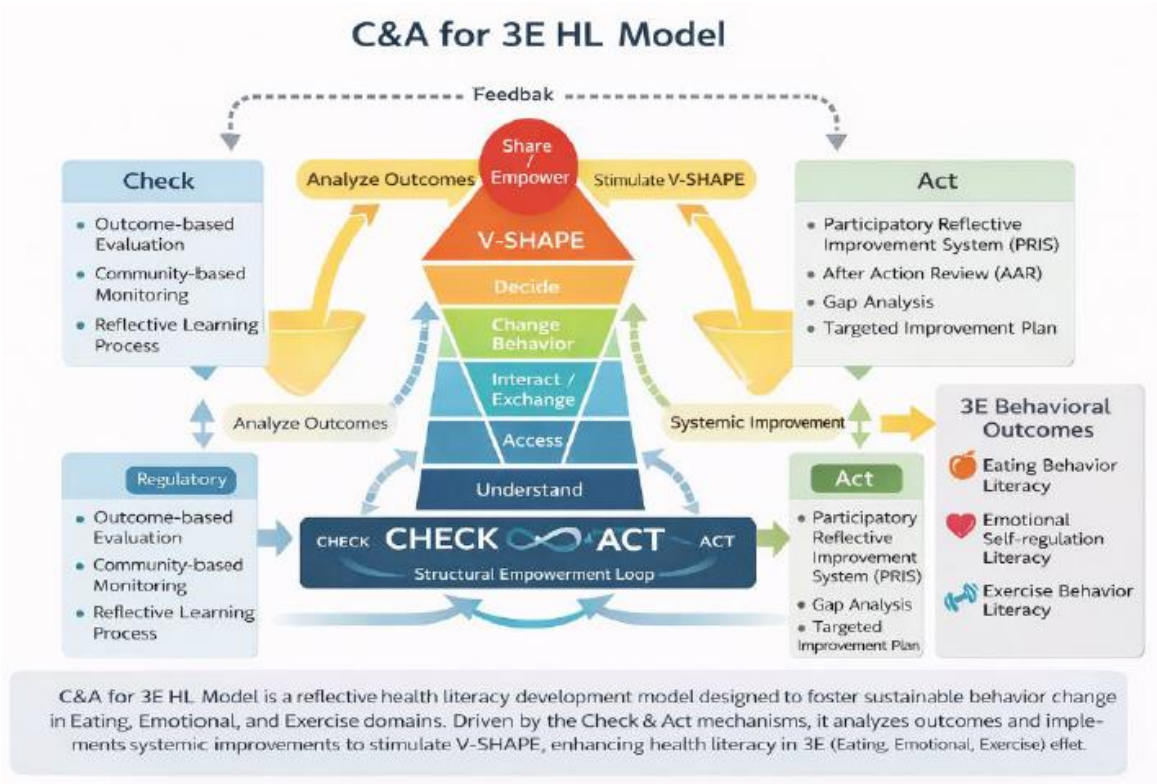
In this phase, inferential statistical analysis was conducted to examine the predictive factors related to management processes for health literacy development and health-promoting behaviors in the domains of dietary practices, emotional well-being, and physical activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province. The results of regression analyses are presented in Table 5.

Table 5 shows the Multiple Regression Analysis Predicting Health-Promoting Behaviors (Eating, Emotional Well-being, and Physical Activity)

Predictor	Promoting Healthy Eating, Emotional Health, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi			
	B	S.E.b	Beta	Sig
Check	.58	.09	.492	.000
Act	.34	.12	.224	.005
Constant	.59	.38		.135
R	.65			
R^2 adj	.42			

Multiple regression analysis indicated that the Check (B = 0.58, SE = 0.09, Beta = 0.492, p < .001) and Act (B = 0.34, SE = 0.12, Beta = 0.224, p = .005) components significantly predicted health-promoting behaviors. The model explained 42% of the variance (Adjusted R^2 = 0.42) with a multiple correlation coefficient of 0.65.The predictive equation in raw score form was: $\hat{Y}$ = 0.59 + (0.58 × Check) + (0.34 × Act)

5. A Health Literacy Development Model for Promoting Healthy Eating, Physical Activity, and Emotional Well-being among Village Health Volunteers in Bang Yai District, Nonthaburi Province



The proposed model, termed the "C&A for 3E Health Literacy Model," was empirically derived from multiple regression analysis, in which healthy eating, emotional health, and physical activity emerged as significant outcome variables (3E). These components represent the core domains of health behavior targeted in this study. Furthermore, the model incorporates management principles, particularly the "Check" and "Act" phases of the PDCA cycle, as key operational mechanisms. These processes emphasize ongoing monitoring, evaluation, and adaptive improvement, ensuring that health literacy interventions are responsive and sustainable within the context of Village Health Volunteers.

Summary of Research Findings

Current Status of Management Processes for Health Literacy Development in Promoting Healthy Eating, Emotional Well-being, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province

The analysis of management processes based on the PDCA framework indicated that the overall level was moderate. When examined by component, the Act

dimension demonstrated the highest mean score at a high level and ranked first, reflecting that the sample group systematically applied evaluation findings to continuously improve and develop operational performance. This was followed by the Plan component at a moderate level (ranked second), the Do component at a moderate level (ranked third), and the Check component, which showed the lowest mean score yet remained within the moderate level (ranked fourth).

These findings indicate that although the overall management process was at a moderate level, greater strength was observed in the improvement phase compared with other stages. In contrast, the monitoring and evaluation phase requires further strengthening to ensure that the PDCA cycle operates comprehensively and achieves optimal effectiveness.

At the item level, most activities were rated at a moderate level. The highest mean score was observed for "Development of sustainable health operational guidelines" (ranked first), followed by "Expansion of health promotion activities in the subsequent fiscal year" (ranked second), and "Target group participation in planning health activities" (ranked third). These results reflect strong performance in continuous improvement and community participation.

Conversely, the lowest mean scores were found in "Post-activity evaluation of health knowledge or behaviors" (ranked sixteenth) and "Situation analysis including strengths, weaknesses, opportunities, and threats" (ranked fifteenth). Although these items remained at a moderate level, they were comparatively lower than others, indicating that situational analysis and systematic evaluation processes require further development. Overall, the findings highlight that the Act phase is the most prominent component, whereas the Check phase and aspects of the Plan phase represent areas requiring reinforcement to ensure a complete and effective PDCA management cycle capable of sustaining community health outcomes. The proposed "C&A for 3E Health Literacy Model" extends existing frameworks by combining three behavioral domains (healthy eating, emotional health, and physical activity) with continuous monitoring and improvement processes.

Current Status of Health Literacy Development in Promoting Healthy Eating, Emotional Well-being, and Physical Activity among Village Health Volunteers in Bang Yai District, Nonthaburi Province

The analysis of health literacy behaviors based on the V-SHAPE framework indicated that the overall level was moderate. Among the dimensions, Access ranked highest, followed by Interact/Exchange and Understand. The lowest mean scores were observed in Share/Empower, followed by Change Behavior and Decide.

These findings suggest that while respondents demonstrated the ability to access health information and engage in knowledge exchange to a certain extent, progression toward decision-making, sustained behavioral modification, and empowerment for knowledge dissemination remains relatively limited. This pattern indicates the need to strengthen mechanisms that facilitate the transition from information awareness to practical application and community-level expansion.

At the item level, all indicators were rated at a moderate level. The highest mean score was observed in "Participation in health-related discussions within the group" (ranked first), followed by "Adequate access to health information channels" (ranked second), and "Consistent application of health knowledge in daily life" (ranked third).

In contrast, the lowest mean scores were found in "Confidence in serving as a health role model to encourage appropriate behavior change" (ranked twelfth) and "Dissemination of health knowledge to family or community members" (ranked eleventh). These findings indicate that the Share/Empower dimension remains comparatively weaker than other components. Overall, while participants demonstrated moderate competence in access and participation, advancement toward sustained behavior change and community empowerment was less evident, underscoring the need to develop supportive mechanisms that enable Village Health Volunteers to become sustainable community health change agents.

Analysis of Management Factors Influencing Health Literacy Behaviors

Multiple regression analysis revealed that the Check and Act components of the management process significantly predicted health literacy behaviors related to healthy eating, emotional well-being, and physical activity at the .05 significance level.

The Check component showed a statistically significant positive influence (B = .58, S.E. = .09, Beta = .492, p < .001), indicating that enhanced monitoring, supervision, and evaluation were associated with significant increases in health literacy behaviors and represented the strongest predictor in the model.

Similarly, the Act component demonstrated a statistically significant positive effect (B = .34, S.E. = .12, Beta = .224, p = .005), suggesting that the systematic application of evaluation findings for continuous improvement contributes to enhanced health literacy behaviors.

The multiple correlation coefficient (R) was .65, indicating a relatively strong relationship between independent and dependent variables. The adjusted R^2 value of .42 indicates that management process variables explained 42% of the variance in health literacy behaviors, representing a moderate to moderately high explanatory power for research in social and public health sciences.

Discussion

The findings of this study on "A Health Literacy Development Model for Promoting Healthy Eating, Physical Activity, and Emotional Well-being among Village Health Volunteers in Bang Yai District, Nonthaburi Province" can be discussed according to the research objectives as follows.

First, the PDCA-based management processes were overall at a moderate level. Notably, the Check and Act components significantly predicted health literacy behaviors and accounted for 42% of variance, indicating that monitoring and continuous improvement mechanisms are central to strengthening Village Health Volunteers' systematic learning capacity. These findings align with Deming's quality management cycle, emphasizing evidence-based decision-making and continuous improvement. They are also consistent with Thailand's primary care reform emphasizing results-based monitoring and data-driven management (Ministry of Public Health, 2022).

These findings correspond with Nutbeam (2017), who argued that community health literacy development requires organizational structures that support reflective practice and empowerment processes. Sørensen et al. (2016) further highlighted that health literacy extends beyond individual skills and is shaped by organizational and

systemic contexts. Similarly, studies conducted by the Faculty of Public Health, Mahidol University (2021), found that primary care units with structured monitoring systems demonstrated significantly stronger continuity in Village Health Volunteers' health behaviors.

Second, according to the V-SHAPE framework, Access and Interact/Exchange scored higher than Share/Empower and Change Behavior. This pattern suggests that health literacy among Village Health Volunteers remains predominantly at functional and interactive levels rather than critical and empowerment levels. This aligns with the Department of Health's national health literacy survey (2020), which reported that most Thai citizens demonstrate basic health literacy but lack critical decision-making and empowerment competencies.

Osborne et al. (2016–2020) emphasized that progression from understanding to sustained behavior change requires coaching processes, reflective mechanisms, and social support—elements closely linked to the Check and Act stages of PDCA. The findings thus demonstrate a theoretically coherent structural relationship between management processes and behavioral health literacy outcomes.

Furthermore, research conducted by Chiang Mai University (2019) found that reflective learning platforms and structured community dialogue significantly enhanced Village Health Volunteers' confidence as health leaders, corresponding with the comparatively lower scores observed in the Share/Empower dimension in this study.

In summary, the findings confirm that an effective health literacy development model for Village Health Volunteers should be grounded in systematic PDCA-based management-particularly strengthening monitoring and continuous improvement mechanisms-while simultaneously enhancing critical competencies and empowerment capacities within the V-SHAPE framework. Such integration facilitates progression from information access to sustainable community health leadership. This study demonstrated that health literacy significantly influences healthy eating, emotional health, and physical activity among Village Health Volunteers. These findings highlight the critical role of health literacy in shaping multiple dimensions of health behavior. This relationship may be explained by the functional role of VHVs as key actors in primary healthcare systems. Individuals with higher health literacy are more capable of accessing, understanding, and applying health information, which supports effective decision-making and behavior

modification.These findings are consistent with previous international studies. Don Nutbeam (2017) emphasized that health literacy is a fundamental determinant of health behavior, while Kristine Sørensen et al. (2012) identified health literacy as a multidimensional construct influencing health outcomes.Importantly, this study extends existing knowledge by integrating health literacy with management principles, particularly the Check and Act processes. This approach enhances the sustainability of behavior change by incorporating continuous monitoring and adaptive improvement mechanisms. However, the study has some limitations, particularly regarding the sampling approach, which may limit generalizability. Nevertheless, the findings provide valuable insights for developing effective and sustainable health promotion models in community settings.

Recommendations

Practical Recommendations

Based on the research findings indicating that the PDCA management cycle-particularly the Check and Act components-significantly influenced health literacy behaviors, while the Share/Empower dimension of the V-SHAPE framework remained at a moderate-to-low level, the following practical recommendations are proposed:

1. **Development of a Qualitative Monitoring and Evaluation System**

Evaluation instruments should be developed to assess post-activity outcomes encompassing knowledge levels, decision-making skills, and behavioral changes. Outcome-based Evaluation and Community-based Monitoring approaches should be applied to ensure that the Check stage functions as a reflective learning mechanism rather than merely a documentary reporting process.

2. **Establishment of Structured Reflection and Learning Platforms**

Regular Reflection Forums at the subdistrict or district level should be organized to enable Village Health Volunteers to reflect on operational outcomes, analyze strengths and weaknesses, and collaboratively design improvement strategies. This approach would simultaneously strengthen the Interact and Share/Empower dimensions.

3. **Enhancement of Health Leadership and Empowerment Capacity**

A Health Leadership Development Program should be designed for Village Health Volunteers, emphasizing motivational communication skills, behavioral

role modeling, and community empowerment strategies to elevate the Share/Empower dimension, which represents the culminating stage of the V-SHAPE framework.

4. Establishment of a Participatory Reflective Improvement System (PRIS)

A district-level Participatory Reflective Improvement System should be developed, requiring all health promotion activities conducted by Village Health Volunteers to undergo a three-step process:

1. After Action Review (AAR)
2. Gap Analysis between expected and actual outcomes
3. Development of a Targeted Improvement Plan for the subsequent cycle

5. Integration of PDCA and V-SHAPE in District-Level Planning

The District Health Office should incorporate research findings into strategic planning by integrating PDCA as the management structure and V-SHAPE as the outcome framework, thereby establishing a management system that explicitly links operational processes with behavioral health outcomes.

6. Development of a Mentoring System

A structured mentoring or health coaching system should be implemented for newly recruited Village Health Volunteers, utilizing high-performing volunteers as role models to facilitate tacit knowledge transfer and foster a culture of continuous learning within the community.

7. Utilization of Technology to Support Learning

Digital platforms such as Line Official Accounts or mobile applications should be promoted to enhance continuous access to health information (Access) and ongoing monitoring (Check), particularly in semi-urban contexts with adequate digital infrastructure.

Recommendations for Future Research

To advance theoretical and empirical knowledge in community-based health literacy development, the following research directions are proposed:

1. Experimental or Quasi-Experimental Design

Future studies should employ experimental or quasi-experimental designs to test the PDCA-driven Health Literacy Model developed from this research by comparing intervention and control groups to establish causal inference.

2. Structural Equation Modeling (SEM)

Future research should examine the structural relationships between PDCA and V-SHAPE using Structural Equation Modeling to test causal pathways, including potential mediating variables such as self-efficacy or health leadership.

3. Comparative Studies Across Contexts

Comparative research should be conducted across urban, semi-urban, and rural settings to analyze the influence of socioeconomic and contextual factors on the effectiveness of the proposed model.

4. In-Depth Qualitative Research

Qualitative methodologies such as in-depth interviews or focus group discussions should be employed to explore Village Health Volunteers' experiences, perceptions, and barriers in progressing toward the Share/Empower level.

5. Policy and Systems-Level Research

Further studies should analyze the role of provincial and national policies in strengthening community-level health literacy to bridge research findings with broader health system development.

6. Longitudinal Studies

Long-term follow-up studies should be conducted to assess the sustainability of health behavior changes among Village Health Volunteers and to evaluate the long-term effectiveness of PDCA mechanisms in maintaining outcomes.

Acknowledgment

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An Intelligent Vision System for Product Label and Banknote Recognition for Visually Impaired Assistance

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Abstract

Visual impairment significantly limits individuals' ability to independently perform daily tasks such as identifying banknotes and reading product labels, leading to potential errors in financial transactions and reduced accessibility to essential information. This study proposes an intelligent vision-based assistive system that integrates barcode detection with ORB (Oriented FAST and Rotated BRIEF) feature matching to enable accurate and real-time object recognition on mobile devices. The system captures images via a smartphone camera and provides audio feedback through a text-to-speech mechanism to support visually impaired users. Experimental results demonstrate that the proposed system achieves an overall recognition accuracy of 96.2%, with 94.6% for product labels and 97.8% for banknotes, along with an AUC of 0.97 and an average processing time of approximately 1.80 seconds. The system also exhibits balanced classification performance with high precision, recall, and F1-score values. A user evaluation involving 30 visually impaired participants confirms that the system improves task performance and usability, particularly with minimal training. These findings suggest that the proposed hybrid approach offers a robust, efficient, and practical solution for real-world assistive applications, thereby contributing to the development of intelligent technologies that enhance accessibility, support independent living, and align with the vision of a smart ageing society.

Keywords: Assistive Technology, Computer Vision, Barcode Detection, ORB Feature Matching, Visually Impaired, Smart Ageing Society

Background and Statement of the problem

Visual impairment is a significant challenge that affects an individual's ability to interact with their surroundings and perform daily activities independently. According to

the World Health Organization (WHO, 2023), at least 2.2 billion people globally have a vision impairment or blindness, of which a significant proportion is preventable or remains unaddressed. Individuals with visual impairment often experience difficulties when identifying product information, reading labels, or recognizing banknotes during financial transactions. According to the Thailand Association of the Blind, many still rely on assistance from others when accessing product information or handling money, which can limit their independence and quality of life (Changsee, personal communication, 2024; Khadwong, personal communication, 2024).

To address these challenges, various assistive technologies have been developed using computer vision and mobile technologies. Mobile-based recognition systems, for example, allow users to capture images of objects and receive audio feedback describing the recognized information (Suriyaporn, 2018). However, many existing systems are designed to recognize only a single type of object, such as banknotes or text labels, which limits their practicality in everyday situations.

Several studies have explored barcode recognition techniques for product identification. Barcode detection has been widely applied in manufacturing and inventory management systems because of its reliability and structured data format (Chuchuay, 2017). In addition, mobile barcode readers have been developed to assist users in identifying consumer products by decoding barcode information captured through mobile cameras (Jetjarurat, 2013).

Image processing techniques have also been applied in assistive applications. For example, automated systems have been developed to identify pharmaceutical labels and related documentation to improve medication safety (Sriborrirak, 2018). Furthermore, pattern recognition and character recognition algorithms have been widely studied in computer vision to enhance the accuracy of visual recognition systems (Endo, 2012). These studies demonstrate the potential of image recognition technologies for improving accessibility.

Despite these developments, most existing approaches focus on a single recognition method or a single object category, which may limit their effectiveness in real-world assistive applications. In practical scenarios, users often encounter diverse objects under varying environmental conditions, such as changes in lighting, occlusion,

and viewing angles. Relying on a single recognition technique may therefore reduce system robustness and lead to inconsistent performance. Furthermore, many existing systems are designed and evaluated under controlled conditions. This may not fully reflect real-world usage, where multiple object types must be recognized within a single interaction. In practice, users often need to identify multiple types of objects, including product labels and banknotes, using the same assistive tool. Therefore, there is a need for an integrated recognition approach that combines complementary techniques to improve accuracy, robustness, and practical usability in real-world environments.

Based on this motivation, this research proposes an intelligent vision-based recognition system that integrates barcode detection and ORB (Oriented FAST and Rotated BRIEF) feature matching techniques to recognize both product labels and Thai banknotes. The proposed system is designed to achieve high recognition accuracy while maintaining near real-time performance and usability on mobile devices, thereby supporting independent living and contributing to the development of assistive technologies for a smart ageing society.

Objective

The objectives of this research are as follows:

1. To design and develop an intelligent vision-based assistive system capable of recognizing product labels and Thai banknotes for visually impaired users.
2. To integrate barcode detection and ORB feature matching techniques for object recognition in mobile-based assistive applications.
3. To evaluate the performance of the proposed system in terms of recognition accuracy and classification performance using product label and banknote datasets.
4. To analyze the processing efficiency of the system by measuring the average processing time required for object recognition.
5. To conduct a user experiment with visually impaired participants to examine the usability of the proposed system and analyze task success rates during object recognition tasks.

Expected benefits

The expected benefits of this research are as follows:

1. Development of an assistive recognition system that enables visually impaired individuals to identify product labels and banknotes in daily life.
2. Enhancement of independence and accessibility through real-time audio-based object recognition on mobile devices.
3. Demonstration of a practical and efficient hybrid recognition approach by integrating barcode detection with ORB feature matching for mobile assistive applications.
4. Contribution to the development of intelligent assistive technologies that support independent living and improve quality of life for visually impaired individuals within a smart ageing society.

Literature Review

Recent advancements in computer vision and mobile technologies have significantly enhanced the development of assistive technologies designed to support visually impaired individuals. Numerous studies have focused on object recognition systems that enable users to identify objects through image processing combined with audio feedback mechanisms.

One of the fundamental approaches for assisting visually impaired users is barcode recognition. Jetjarurat (2013) developed a mobile barcode reader specifically for visually impaired individuals in Thailand, allowing users to capture barcode images via a smartphone camera and receive product information through audio output. Similarly, Chuchuay (2017) proposed an image-based barcode detection method for industrial product classification, demonstrating high reliability under controlled conditions. However, barcode-based approaches are highly dependent on barcode visibility and may fail in cases of occlusion, distortion, or damaged labels.

In parallel, image-based recognition techniques have been widely explored for assistive applications. Sriborrirak (2018) developed an automated system for identifying pharmaceutical labels to enhance medication safety, while Suriyaporn (2018) proposed a real-time mobile application for recognizing Thai banknotes. Although these systems

achieved high accuracy, their performance is often sensitive to environmental variations such as lighting conditions and background noise.

Feature-based methods have also played a significant role in object recognition. Lowe (2004) introduced the Scale-Invariant Feature Transform (SIFT), followed by the Speeded-Up Robust Features (SURF) algorithm proposed by Bay et al. (2008), which improved computational efficiency. To further support real-time applications, Rublee et al. (2011) proposed the ORB (Oriented FAST and Rotated BRIEF) algorithm, which enables fast and efficient feature extraction and matching. Due to its low computational cost, ORB is particularly suitable for mobile-based assistive systems.

More recently, deep learning approaches have significantly advanced object recognition performance. Redmon et al. (2016) introduced the YOLO framework for real-time object detection, while He et al. (2016) proposed the ResNet architecture for improving classification accuracy. Despite their effectiveness, these approaches typically require large-scale datasets and high computational resources, which may limit their applicability in lightweight mobile environments.

In addition to recognition techniques, prior studies have emphasized the importance of system design and user-centered development in assistive technologies. Ngamsantivong (2006) highlighted the role of structured system design while proposing a model-driven development approach for flexible applications. User requirements have also been investigated through interviews with visually impaired individuals (Changsri, 2021; Khadwong, 2021), indicating that simplicity, accuracy, and real-time audio feedback are critical factors in assistive system adoption. Furthermore, Endo (2012) demonstrated that variation-based learning can improve recognition performance in noisy environments, reinforcing the importance of robustness in real-world applications.

Based on the reviewed literature, it is evident that most existing systems rely on a single recognition approach, such as barcode detection, OCR, or image-based classification. While these methods are effective in specific contexts, they often struggle to handle diverse real-world scenarios where multiple object types and varying environmental conditions are present. Moreover, existing solutions typically address either product identification or currency recognition independently, rather than providing a unified system.

Therefore, this study proposes a hybrid intelligent vision system that integrates ORB feature matching with barcode detection to enhance recognition accuracy, robustness, and real-time performance. Unlike previous approaches, the proposed system supports both product label and banknote recognition within a single mobile platform, addressing the practical needs of visually impaired users in everyday situations.

Conceptual Framework

The conceptual framework of this study is developed based on established research in assistive technologies, computer vision, and mobile object recognition systems. Vision-based assistive systems have been shown to significantly improve accessibility for visually impaired users by enabling automatic object recognition and auditory feedback (Jetjarurat, 2013; Suriyaporn, 2018). Barcode recognition techniques are widely applied in product identification due to their reliability in decoding structured information (Chuchuay, 2017), while feature-based methods such as ORB (Oriented FAST and Rotated BRIEF) provide efficient and robust real-time recognition under varying conditions (Rublee et al., 2011; Endo, 2012). From a system design perspective, this study adopts the Input–Process–Output (IPO) model to represent the flow of data and system functionality (Laudon & Laudon, 2018).

Based on these foundations, this research proposes an integrated recognition framework that combines barcode detection and feature-based recognition to enhance object identification performance in real-world environments. The framework consists of three main components: input, processing, and output. The input component involves image acquisition using a mobile device camera. The captured image is then processed through image preprocessing, barcode detection, and ORB feature matching to support accurate object recognition.

From a conceptual perspective, the framework explicitly represents the relationship between key system components. Image Acquisition serves as the input stage, followed by Image Processing, which enhances image quality and prepares data for analysis (Gonzalez & Woods, 2018). The processed data is then passed to the Object Recognition stage, where barcode detection and ORB feature matching are applied. The results are delivered through the output stage as Audio Feedback using a text-to-speech

module, aligning with assistive interaction principles for visually impaired users (Stephanidis, 2019). These components operate as an integrated pipeline that transforms visual input into meaningful auditory information in near real-time.

To support systematic evaluation, key variables are defined in terms of both technical performance and usability. Recognition Accuracy, Precision, Recall, and F1 - score are used to evaluate classification performance (Sokolova & Lapalme, 2009), while Processing Time measures system efficiency. User Task Success Rate is used to assess usability in real-user experiments. This framework forms the foundation for the system development and experimental design presented in the methodology section, and is illustrated in Figure 1.

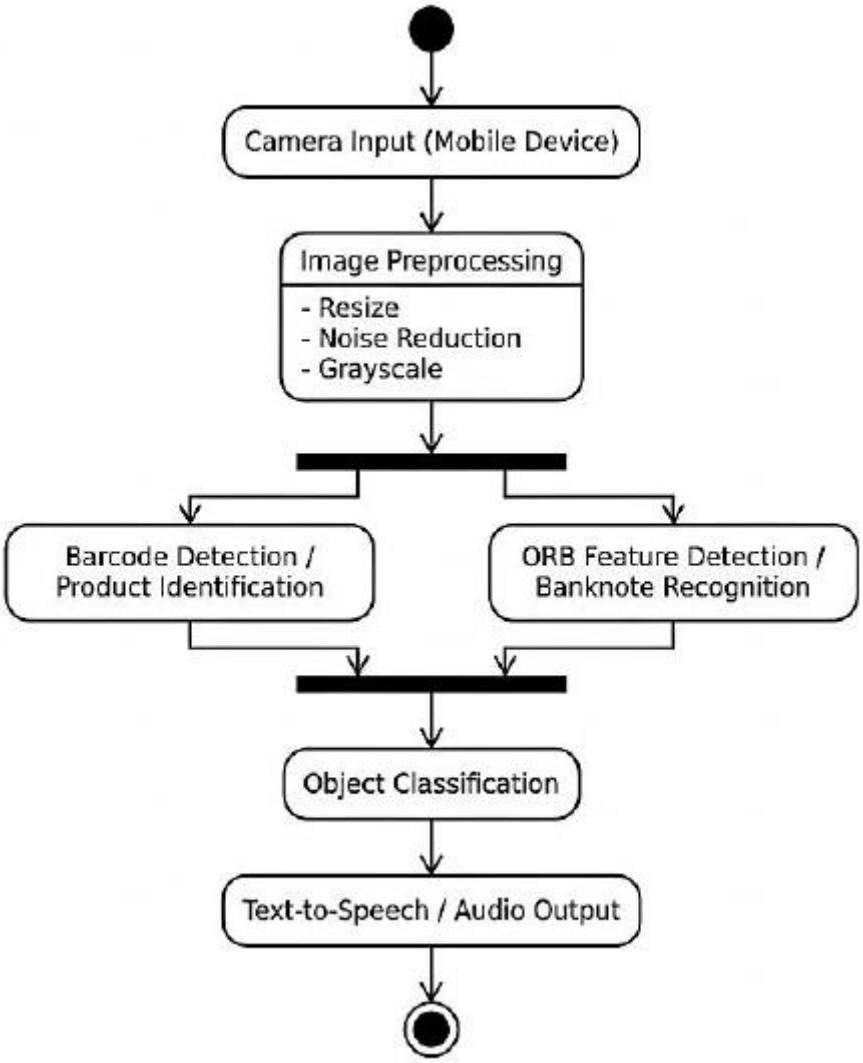


Figure 1 Conceptual Framework of the Proposed Assistive Recognition System

Research Methodology

This study presents the development and evaluation of an intelligent vision-based recognition system designed to assist visually impaired users in identifying product labels and Thai banknotes. The methodology consists of four main stages: dataset preparation, barcode detection, ORB feature matching, and system performance evaluation.

1. Dataset Preparation

A dataset was constructed using images collected from real-world environments such as supermarkets and convenience stores, following prior assistive product identification studies (Jetjarurat, 2013). The dataset consists of two categories: product labels and Thai banknotes.

For product recognition, 300 types of product labels were collected, resulting in 3,427 images captured under varying lighting conditions, orientations, and packaging materials. As shown in Figure 2, each label includes key attributes such as product name, barcode, and expiration date. For banknote recognition, five Thai denominations (20, 50, 100, 500, and 1,000 Baht) were used, as illustrated in Figure 3, with a total of 500 images captured under different viewing conditions.



(a) Product name (b) Barcode information (c) expiration date characters

Figure 2 Product label contains



Figure 3 Examples of Thai banknotes used in the dataset

The dataset was divided into training and testing sets using an 80:20 split. The training set was used to construct the reference feature database, while the testing set was used for performance evaluation. Data augmentation techniques, including rotation, brightness adjustment, and scaling, were applied to improve robustness. A summary of the dataset is presented in Table 1.

Table 1 Dataset Description

Dataset Category	Number of Classes	Total Images	Training Images (80%)	Testing Images (20%)	Description
Product Labels	300 types	3,427	2,742	685	Images of product packaging collected from supermarkets and convenience stores under different lighting conditions and viewing angles
Thai Banknotes	5 types	500	400	100	Images of Thai currency denominations (20, 50, 100, 500, 1,000 Baht) captured using a mobile camera
Total	305	3,927	3,142	785	Combined dataset used for training and evaluation

2. Barcode Detection

Barcode detection is applied as the first stage of product identification due to its reliability in extracting structured product information (Chuchuay, 2017). The implementation was conducted using the pyzbar library in Python.

The barcode detection process, illustrated in Figure 4 and Figure 5, includes grayscale conversion, edge enhancement, noise reduction, thresholding, morphological operations, and contour detection to localize barcode regions. Once detected, barcode information is decoded and matched with the product database. If barcode detection fails due to occlusion, poor image quality, or the absence of barcode patterns, the system proceeds to feature-based recognition.

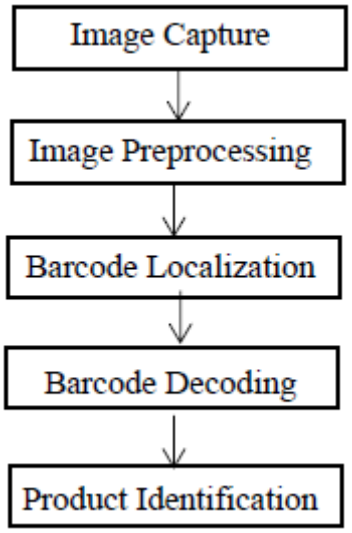


Figure 4 Barcode Detection Process

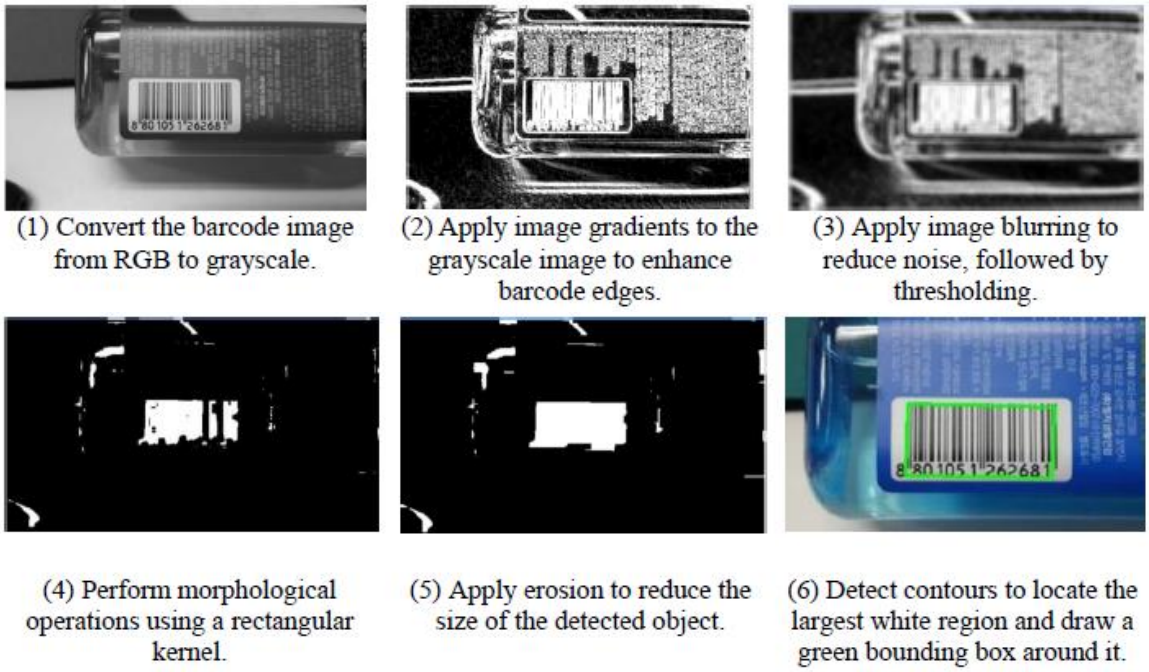


Figure 5 Barcode detection process consisting of six processing steps

3. ORB Feature Matching

When barcode detection is unsuccessful, ORB (Oriented FAST and Rotated BRIEF) feature matching is applied for object recognition. The overall process is shown in Figure 6, with classification examples presented in Figure 7. ORB combines the FAST keypoint detector and BRIEF descriptor to extract distinctive features, which are matched against a reference database using Hamming distance (Rublee et al., 2011; Endo, 2012).

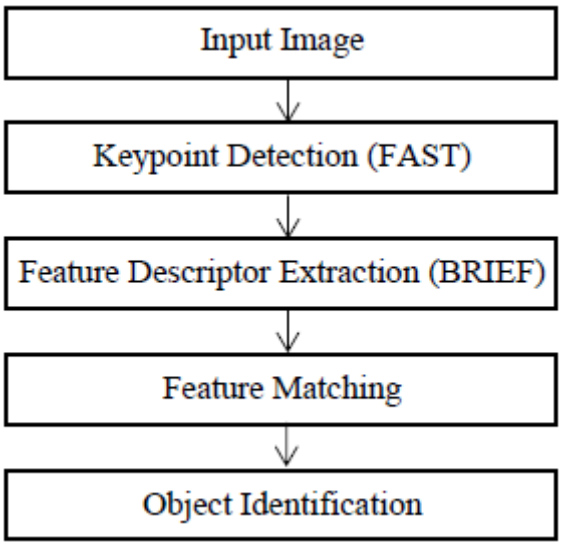


Figure 6 ORB Feature Matching

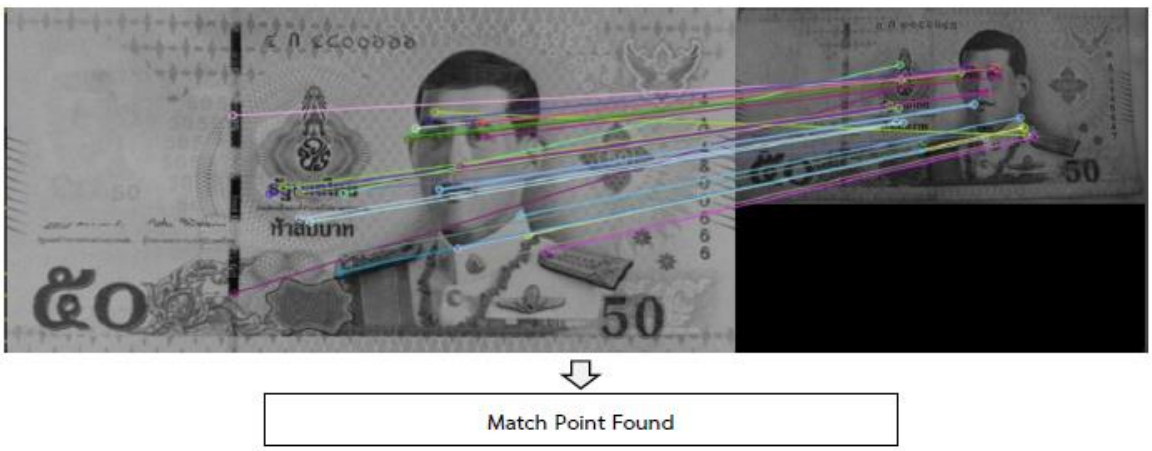


Figure 7 Example of Thai Banknote Classification.

4. Algorithm Formulation

This section describes the mathematical formulation used in the object recognition process, including ORB feature extraction and similarity matching.

4.1 ORB Feature Detection

The ORB algorithm combines the FAST keypoint detector and the BRIEF descriptor to extract distinctive features from images. The FAST detector identifies corner points in an image by evaluating the intensity differences between a candidate pixel and its surrounding pixels.

A pixel pis classified as a keypoint if the intensity difference between the center pixel and surrounding pixels exceeds a predefined threshold t.

$$|I(p) - I(p_i)| > t$$

where *I(p)* is the intensity of the center pixel, $I(p_i)$is the intensity of surrounding pixels and t is the intensity thresh old.

4.2 Feature Descriptor Matching

After feature extraction, the similarity between descriptors from the captured image and reference images is calculated using the Hamming distance.

$$D_H(x, y) = \sum_{i=1}^{n} x_i \oplus y_i$$

where x *and* y represent binary feature descriptors, $\oplus$ denotes the XOR operation and n is the descriptor length.A match is considered valid when the Hamming distance is below a predefined threshold.

4.3 Recognition Decision

The final recognition decision is determined by selecting the reference object that produces the highest number of valid feature matches.

$$R = \arg\max_i (M_i)$$

where M_i is the number of matched features for the object i, R represents the recognized object.

5. System Implementation and Experimental Setup

The proposed system was implemented using Python on a mobile-based platform. Experiments were conducted on a smartphone device running the Android operating system, with image processing and recognition implemented using OpenCV and pyzbar libraries.

6. Performance Evaluation

The system performance was evaluated using both quantitative metrics and user-based evaluation. Recognition Accuracy was calculated based on True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN). In addition, Precision, Recall, and F1-score were used to evaluate classification performance, supported by confusion matrix analysis (Sokolova & Lapalme, 2009). Processing Time was also measured to assess system efficiency in real-time usage.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

7. User Experiment and Ethical Considerations

A user study was conducted with 30 visually impaired participants to evaluate system usability and task performance. Participants were recruited using purposive sampling from a visually impaired community group. All participants provided informed consent prior to the experiment, and the study followed standard ethical guidelines for human-centered research.

During the experiment, participants performed object recognition tasks using the proposed system. User Task Success Rate was measured to evaluate usability and effectiveness in real-world scenarios.

This methodology aligns with the conceptual framework by integrating image acquisition, processing, object recognition, and audio feedback into a unified evaluation pipeline.

Research Results

The proposed intelligent vision system was comprehensively evaluated through both quantitative performance analysis and real-user experiments. The evaluation framework consists of seven key aspects: (1) system interface demonstration, (2) recognition accuracy, (3) product label recognition performance, (4) confusion matrix and classification metrics, (5) ROC curve analysis, (6) processing time evaluation, (7) user evaluation, and (8) comparison with existing methods.

1. System Interface and Operation

The user interface of the proposed assistive recognition system is illustrated in Figure 8. The system was designed with accessibility as a primary consideration, providing a simple and intuitive interface tailored for visually impaired users.



(a) Login screen

(b) System function interface

(c) Simulation of product label and Thai banknote scanning.

Figure 8 User interface of the proposed assistive recognition system

The interface supports real-time camera input and provides audio feedback following recognition, thereby enabling effective user interaction.

2. Recognition Accuracy

The recognition accuracy of the proposed system was evaluated using a dataset consisting of product labels and Thai banknotes captured under diverse environmental conditions.

As presented in Table 2, the proposed system achieved an overall accuracy of 96.2%, with 94.6% for product labels and 97.8% for banknotes. The higher accuracy observed in banknote recognition can be attributed to the more distinctive visual features and standardized structure of currency images, compared to the variability in product packaging.

Table 2 Recognition Accuracy Results

Object Type	Accuracy
Product Labels	94.6%
Banknotes	97.8%
Overall Accuracy	96.2%

These results highlight the effectiveness of the hybrid approach, where barcode detection provides reliable identification when structured information is available, while ORB feature matching compensates in cases where barcode detection fails. This complementary mechanism significantly improves robustness in real-world scenarios compared to single-method approaches.

3. Product Label Recognition Performance

The product label recognition module is based on barcode detection and decoding techniques. The evaluation results in Table 3 show that the system achieved a barcode detection rate of 97.8% and a decoding accuracy of 96.5%, resulting in an overall product recognition accuracy of 95.4%.

Table 3 Barcode Detection Performance

Metric	Value (%)
Barcode Detection Rate	97.8
Barcode Decoding Accuracy	96.5
Product Recognition Accuracy	95.4

These results indicate that the system maintains robust performance even under challenging conditions such as partial occlusion and varying illumination.

4. Confusion Matrix and Classification Metrics

To further analyze classification performance, a confusion matrix was constructed, as shown in Figure 9.

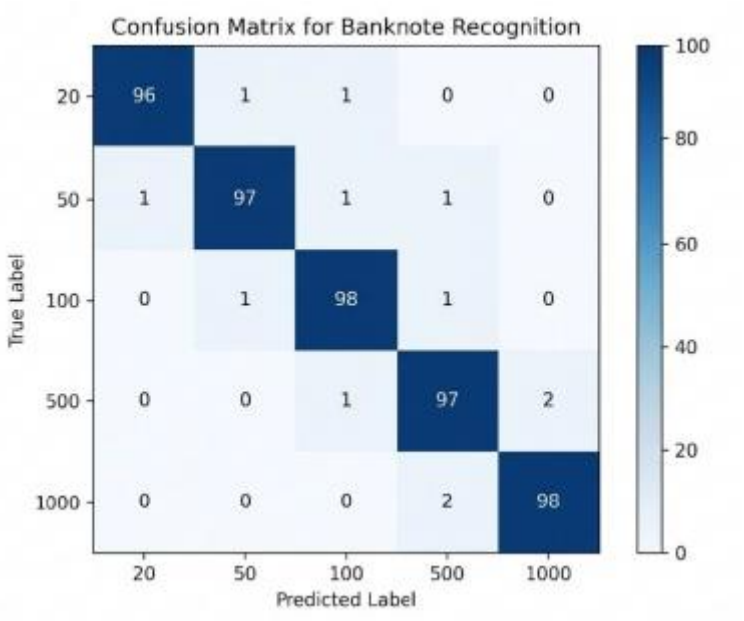


Figure 9 Confusion Matrix Heatmap (5 Classes: 20, 50, 100, 500, 1000 Baht)

The confusion matrix shown in Figure 9 indicates that most predictions are correctly classified, as reflected by strong diagonal values. Minor misclassifications are observed between 500 and 1000 Baht denominations, which can be attributed to visual similarities in color and partial occlusion during image capture.

This observation suggests that while ORB feature matching is robust to rotation and illumination variations, its performance may be affected when discriminative features are insufficiently distinctive. Similar limitations have been reported in feature-based recognition methods (Rublee et al., 2011). Nevertheless, the overall high precision (95.8%) and recall (96.4%) values presented in Table 4 indicate that the system maintains balanced performance with low false positive and false negative rates.

Table 4 Performance Metrics for Banknote Recognition

Banknote Denomination	Precision	Recall	F1-score
20 Baht	0.990	0.980	0.985
50 Baht	0.980	0.970	0.975
100 Baht	0.970	0.980	0.975
500 Baht	0.960	0.970	0.965
1000 Baht	0.980	0.980	0.980
Average	0.958	0.964	0.961

These results confirm that the proposed system achieves high classification reliability with balanced precision and recall performance.

5. ROC Curve Analysis

The Receiver Operating Characteristic (ROC) curve is illustrated in Figure 10. the system achieved an AUC of approximately 0.97, indicating excellent discriminative capability. The ROC curve demonstrates that the system maintains a high true positive rate across varying threshold levels while effectively controlling false positives.

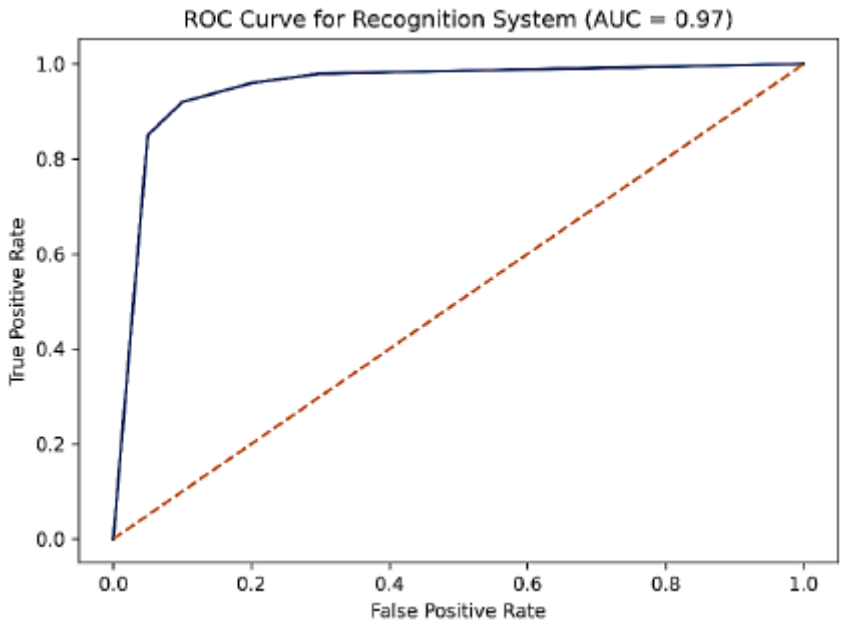


Figure 10 ROC Curve (AUC ≈ 0.97)

This result confirms that the proposed hybrid model provides stable classification performance under different decision thresholds, which is essential for real-world assistive applications where environmental conditions may vary dynamically.

6. Processing Time Evaluation

The processing time of the proposed system was evaluated to assess its efficiency for real-time applications. As shown in Table 5 and Figure 11, the system achieved an average processing time of 1.80 seconds, indicating near real-time performance. The slightly higher processing time for product labels (1.92 seconds) compared to banknotes (1.68 seconds) is likely due to the additional barcode detection and decoding steps.

Table 5 Processing Time Performance

Table 5 Processing Time Performance	
Object Type	Average Processing Time
Product Labels	1.92 seconds
Banknotes	1.68 seconds
Average	1.80 seconds

The processing time performance is illustrated in Figure 11.

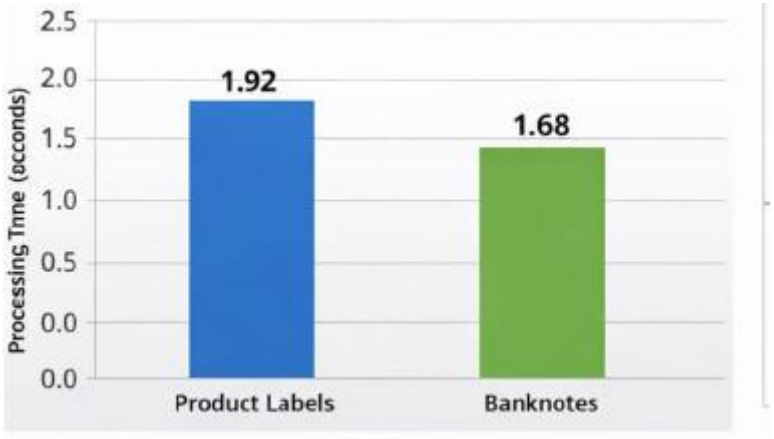


Figure 11 Processing Time Performance of the Proposed System

Despite this variation, the overall processing time remains within acceptable limits for assistive applications, where responsiveness is critical for user interaction. Compared to computationally intensive methods such as deep learning-based models, the proposed approach offers a more efficient solution suitable for mobile deployment.

7. User Evaluation

To evaluate the usability of the proposed recognition system, a user experiment was conducted with 30 visually impaired participants. The participants were divided into two groups based on their level of visual impairment:

- 15 participants with total blindness
- 15 participants with low vision

To analyze the effect of user training, each group was further divided into two subgroups: a trained group and an untrained group. The trained group received a brief introduction and demonstration before using the system, while the untrained group used the system without prior instruction.

The participant distribution is summarized in Table 6.

Table 6 Participant Distribution in User Evaluation

Participant Group	Trained	Untrained	Total
Totally Blind	8	7	15
Low Vision	7	8	15
Total	15	15	30

The results indicate that trained users performed more efficiently and interacted more effectively with the system compared to untrained users.

8. User Task Success Rate

The task success rate for each participant group is summarized in Table 7.

Table 7 User Task Success Rate

Group	Success Rate
Blind (Trained)	94%
Blind (Untrained)	86%
Low Vision (Trained)	96%
Low Vision (Untrained)	88%

The results in Table 7 indicate that trained users achieved higher task success rates (up to 96%) compared to untrained users (as low as 86%). This finding suggests that user familiarity plays a significant role in the effective utilization of assistive technologies.

The performance gap between trained and untrained groups highlights the importance of user-centered design and onboarding processes in assistive system deployment. These findings are consistent with prior studies emphasizing usability and interaction simplicity as key factors in assistive technology adoption (Stephanidis, 2019).

9. Comparison with Existing Methods

The performance of the proposed system was compared with existing approaches, as shown in Table 8., the proposed method achieves competitive accuracy (96.2%) compared to both classical and deep learning-based approaches. While deep learning models such as YOLO and ResNet report slightly higher accuracy, they require substantial computational resources and large-scale training datasets.

Table 8 Comparison with Previous Recognition Systems

Study	Method	Object Type	Accuracy	Key Limitation
Lowe (2004)	SIFT	General Objects	96.0%	High computational cost
Bay et al. (2008)	SURF	General Objects	95.5%	Still computationally intensive
Rublee et al. (2011)	ORB	ORB	95.8%	Less robust than SIFT in complex scenes
Endo (2012)	Feature Variation Model	Characters	91.8%	Limited generalization
Jetjarurat (2013)	Barcode Scanning	Product Labels	92.0%	Requires visible barcode
Redmon et al. (2016)	YOLO	Multi-object Detection	97.0%	Requires large training dataset
He et al. (2016)	ResNet	ResNet	97.5%	High computational resources
Chuchuay (2017)	Image-based Barcode Detection	Industrial Products	94.5%	Limited to structured environments
Sriborrirak (2018)	Image Processing	Image Processing	93.2%	Sensitive to lighting conditions
Suriyaporn (2018)	Image-based Recognition	Banknotes	95.0%	Background noise affects accuracy
Proposed Method (2026)	ORB + Barcode Hybrid	Labels + Banknotes	96.2%	Minor confusion in similar classes

In contrast, the proposed hybrid approach provides a balanced trade-off between accuracy, computational efficiency, and practical usability. Unlike traditional barcode-only systems, the integration of ORB feature matching enables recognition even in the absence of visible barcodes. This makes the proposed system more adaptable to

real-world conditions, where object visibility and environmental factors cannot be controlled.

Summary of the Study

This study proposed an intelligent vision-based recognition system to assist visually impaired individuals in identifying product labels and Thai banknotes by integrating barcode detection and ORB feature matching. The proposed hybrid approach enhances recognition robustness by combining structured barcode decoding with feature-based object recognition in real-world environments.

Experimental results demonstrated that the system achieved an overall accuracy of 96.2%, with balanced performance reflected by a precision of 95.8%, recall of 96.4%, and F1-score of 96.1%. Confusion matrix analysis indicated that most objects were correctly classified, with only minor misclassifications occurring between visually similar banknote denominations. The system also achieved an average processing time of 1.8 seconds, supporting near real-time performance on mobile devices.

User evaluation with 30 visually impaired participants showed high task success rates, with improved performance observed among trained users. This highlights the importance of usability and user familiarity in assistive technology adoption.

Overall, the findings demonstrate that the proposed system provides a reliable, efficient, and practical solution for real-world assistive applications, contributing to enhanced accessibility and supporting independent living for visually impaired individuals in a smart ageing society.

Discussions

The experimental results demonstrate that the proposed intelligent vision system achieves consistently high performance across multiple dimensions, including accuracy, robustness, and usability. The system attained an overall accuracy of 96.2%, confirming the effectiveness of integrating ORB feature matching with barcode detection for real-world assistive applications.

From a technical perspective, the balanced precision (95.8%) and recall (96.4%) indicate that the system effectively minimizes both false positives and false negatives,

which is critical in assistive contexts where recognition errors can directly affect user trust. Confusion matrix analysis further shows that most misclassifications occur between visually similar classes, particularly high-denomination banknotes, highlighting an inherent limitation of feature-based recognition methods when discriminative features are insufficient.

Compared with existing approaches, the proposed system offers a balanced trade-off between accuracy and computational efficiency. Barcode-based systems (Jetjarurat, 2013; Chuchuay, 2017) are reliable but depend on barcode visibility, while feature-based methods such as SIFT (Lowe, 2004) and SURF (Bay et al., 2008) provide robustness at higher computational cost. Deep learning models, including YOLO (Redmon et al., 2016) and ResNet (He et al., 2016), achieve high accuracy but require substantial computational resources and large-scale datasets. The proposed hybrid approach effectively bridges this gap by delivering competitive accuracy with near real-time performance on mobile devices. In terms of usability, the user evaluation highlights the importance of user familiarity. Trained participants achieved significantly higher task success rates than untrained users, consistent with prior studies (Suriyaporn, 2018; Sriborrirak, 2018), which emphasize the role of interaction design and learning curve in assistive technology adoption. The system was effectively used by both totally blind and low-vision participants, indicating that the interface design supports diverse user needs.

A key contribution of this study is the integration of multiple recognition techniques within a unified system capable of handling both product labels and banknotes. Unlike prior work focusing on single-task solutions, this approach better reflects real-world scenarios in which users must identify diverse object types in daily life.

Despite these promising results, several limitations remain. System performance may degrade under extreme lighting conditions or severe occlusion, and reliance on predefined datasets may limit generalization to unseen objects. Future work could explore lightweight deep learning models to enhance adaptability while preserving real-time performance.

Overall, this study demonstrates that combining classical computer vision techniques with application-specific design provides a practical, efficient, and user-

centered solution for mobile assistive systems, with strong potential to enhance accessibility and support independent living for visually impaired users.

Research Contributions

This study provides five key contributions to the field of assistive technology and computer vision: (1) Hybrid Recognition Framework: a novel integration of ORB feature matching and barcode detection that enhances recognition accuracy and robustness in real-world environments; (2) Multi-Object Assistive System: a unified system capable of recognizing both product labels and Thai banknotes, addressing practical daily needs of visually impaired users; (3) Real-Time Mobile Performance: achieves high accuracy (96.2%) with near real-time processing (~1.80 seconds), making it suitable for mobile deployment; (4) User-Centered Validation: demonstrates improved usability and task performance through empirical evaluation with visually impaired participants; and (5) Smart Ageing Assistive Impact: supports independent living and enhances accessibility through real-time audio-assisted recognition, aligning with smart ageing society goals.

Recommendations

Future research may consider the following directions:

1. Integration of lightweight deep learning-based object detection methods to further enhance recognition robustness under complex conditions.
2. Expansion of the dataset to include a broader range of consumer products and more diverse environmental variations.
3. Development of a fully functional mobile application platform to improve accessibility, usability, and real-world deployment.
4. Integration with wearable assistive devices, such as smart glasses, to enable hands-free interaction and continuous user support.

Limitations of the Study

This study has several limitations. The dataset used in the experiments was relatively limited in terms of product diversity and environmental variability. In addition,

system evaluation was primarily conducted in controlled indoor environments, which may not fully reflect real-world conditions. Future research should consider larger-scale datasets and more diverse real-world scenarios to further validate and generalize the robustness of the proposed system.

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The Silent Side of Academia: A Bibliometric Study of Knowledge Hiding

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Abstract

Knowledge hiding has received increasing scholarly attention in organizational research, yet its development within academic settings remains fragmented and insufficiently synthesized. This study provides a comprehensive bibliometric analysis of research on knowledge hiding in academia to clarify the field's intellectual structure, thematic evolution, and emerging research directions. Using a systematic literature review protocol, 39 Scopus-indexed publications were identified and analyzed through established bibliometric techniques. Following recommended procedures, the analysis combines performance indicators with science mapping methods to examine publication trends, influential authors, sources, and institutions, as well as the conceptual structure of the domain. Keyword co-occurrence and thematic mapping were applied to identify dominant research clusters and evolving themes.

The results reveal a rapidly developing but still nascent research field, with increasing scholarly attention since the late 2010s. The literature is primarily grounded in organizational behavior and knowledge management perspectives, emphasizing leadership dynamics, interpersonal relationships, competitive climates, and individual psychological factors that shape knowledge concealment in academic settings. Science mapping further highlights the central role of relational and contextual factors in explaining knowledge hiding behaviors within academia.

By systematically mapping the knowledge base of this emerging research area, the study advances understanding of knowledge hiding among academics and identifies key avenues for future theoretical and empirical development.

Keywords: Knowledge hiding; academia; higher education; bibliometric analysis

Introduction

Knowledge is widely recognized as the most critical resource in contemporary organizations, particularly in knowledge-intensive settings where value creation depends on the generation, integration, and dissemination of expertise (Grant, 1996; Nonaka & Takeuchi, 2007). Universities and research institutions exemplify such contexts, as their core mission, i.e., research, teaching, and service, are fundamentally grounded in knowledge exchange. Normatively, academia is portrayed as an open system that relies on collegiality, peer review, and cumulative knowledge building. However, growing evidence suggests that alongside visible practices of collaboration, academics may also deliberately withhold knowledge from colleagues, students, or collaborators (Hernaus et al., 2019; Mahamed Ismail & Welch, 2023; Modem et al., 2023; Xu & Jiesen, 2022). This less visible phenomenon challenges the idealized image of academia as a purely sharing-oriented community.

The construct of knowledge hiding was formally conceptualized by Connelly et al. (2012), who defined it as an intentional attempt to withhold or conceal knowledge that has been requested by another individual. Importantly, knowledge hiding is distinct from knowledge hoarding or simple non-sharing, as it emphasizes intentionality and interpersonal interaction. Connelly et al. (2012) further identified three primary forms of knowledge hiding: playing dumb, evasive hiding, and rationalized hiding. Since then, a substantial body of research has examined antecedents such as distrust (Connelly et al., 2012; Issac & Baral, 2020; Kumar Jha & Varkkey, 2018), competition (Hernaus et al., 2019), leadership style (Abdillah et al., 2020; Ladan et al., 2017; Offergelt et al., 2019), and psychological ownership (Peng, 2013; Tian et al., 2021), as well as consequences including reduced creative performance (Bogilovic et al., 2017; Butt, 2019a; Černe et al., 2014; Connelly & Zweig, 2015; Malik et al., 2019; Rhee & Choi, 2017), damaged interpersonal relationships (Connelly & Zweig, 2015), and increased turnover intention (Butt, 2019b; Offergelt et al., 2019; Serenko & Bontis, 2016).

Despite this expanding literature, most empirical studies have been conducted in corporate, industrial, or project-based organizational contexts. Comparatively little attention has been paid to academia as a unique organizational setting for knowledge hiding. This omission is notable because academia is known as a work environment

where knowledge is shared. Academics face the dilemma like other organizational employees at work: to share or hide what they know (Connelly & Zweig, 2015; Rhee & Choi, 2017). Even though most academics purposefully sought for knowledge from targeted colleagues, they have, for strategic reasons, hidden their tacit and/or explicit knowledge from others during ongoing research processes (Mahamed Ismail & Welch, 2023). The increasing reliance on performance metrics, citation indicators, and global university rankings has further intensified competitive pressures (Anderson et al., 2007). Under such conditions, withholding research ideas, data, methodological details, or collaborative opportunities may emerge as a strategic response to perceived threats or career risks.

Although individual empirical and conceptual studies have begun to address this phenomenon, the literature remains fragmented across journals, theoretical perspectives, and methodological approaches. The present study combines a systematic literature review (SLR) with bibliometric analysis. The dataset consists of 39 articles indexed in Scopus and identified through a rigorous SLR process following transparent inclusion and exclusion criteria. A systematic literature review meets standards of scholarly rigor and ensures comprehensiveness through the systematic identification and inclusion of all relevant studies (Okoli & Schabram, 2010). Building upon this curated corpus, the author employs the Bibliometrix package and its web interface, Biblioshiny (Aria & Cuccurullo, 2017), to conduct performance analysis and science mapping. Bibliometric techniques enable the identification of influential authors, affiliations, and journals, as well as the exploration of co-citation networks, keyword co-occurrences, and thematic clusters (Donthu et al., 2021; Zupic & Čater, 2015).

Focusing explicitly on academics' knowledge hiding behavior, this study pursues four objectives:

1. To map publication trends and key contributors in research on academic knowledge hiding;
2. To identify the intellectual structure of this research stream;
3. To uncover the thematic landscape and emerging research fronts; and
4. To propose a future research agenda tailored to the institutional characteristics of academia.

By integrating systematic review procedures with bibliometric techniques, this paper contributes to the literature in three ways. First, it consolidates and organizes a dispersed body of research within the broader knowledge hiding domain. Second, it highlights the specific factors that shape knowledge hiding in academia as opposed to corporate environments. Third, it provides a bibliometrically grounded roadmap for advancing scholarship on the "silent side" of knowledge processes in academia. In doing so, this study deepens our understanding of how intentional knowledge concealment coexists with the normative ideals of openness and collaboration that underpin academic life.

Theoretical Background

1. Conceptual Foundations of Knowledge Hiding

Knowledge hiding has emerged over the past decade as a distinct and theoretically grounded construct within the broader knowledge management (KM) literature. Building on earlier discussions of knowledge hoarding and knowledge sharing reluctance, Connelly et al. (2012) provided the seminal definition of knowledge hiding as "an intentional attempt by an individual to withhold or conceal knowledge that has been requested by another person." (Connelly et al., 2012, p. 65). By definition, knowledge hiding requires the presence of two conditions. First, it must be motivated by subjective factors rather than objective constraints, meaning that it involves a deliberate and intentional act. Second, it occurs only in response to a request for knowledge from another individual.

Knowledge hiding is conceptualized as a multidimensional construct comprising three distinct dimensions: playing dumb, evasive hiding, and rationalized hiding (Connelly et al., 2012). Playing dumb occurs when an individual pretends to be ignorant of the requested knowledge and claims an inability to provide assistance, despite actually possessing the relevant information. Evasive hiding refers to situations in which an individual provides incorrect or irrelevant information instead of the requested knowledge, or promises to share the information at a later time without any genuine intention of doing so. Both playing dumb and evasive hiding involve elements of deception to varying degrees (Connelly et al., 2012). In contrast, rationalized hiding does

not necessarily entail deception. Rather, the knowledge holder justifies withholding the requested knowledge by offering seemingly legitimate reasons (e.g., confidentiality constraints or organizational policies). Consequently, individuals engaging in rationalized hiding may perceive their behavior as honest, well-intentioned, and reflective of professional responsibility or competence (Connelly & Zweig, 2015).

Importantly, knowledge hiding is not simply the opposite of knowledge sharing. Empirical studies have demonstrated that knowledge sharing and knowledge hiding are related yet independent constructs (Černe et al., 2014; Connelly et al., 2012). An individual may engage in high levels of sharing in some interactions while deliberately hiding knowledge in others, depending on relational, contextual, and motivational conditions (Issac et al., 2020; Kumar Jha & Varkkey, 2018; Malik et al., 2019; Riaz et al., 2019; Serenko & Bontis, 2016; Shah & Hashmi, 2019; Zhao et al., 2016). This distinction has significant implications for research in academia, where norms of openness coexist with competitive pressures (Anderson et al., 2007).

2. Knowledge Hiding within the Knowledge Management Paradigm

Within the broader KM paradigm, knowledge processes have traditionally been framed positively - emphasizing creation (Nonaka & Takeuchi, 2007), transfer (Argote & Ingram, 2000), integration (Grant, 1996), and sharing (Wang & Noe, 2010). However, as KM matured, scholars increasingly acknowledged that knowledge processes are embedded in social, political, and power-laden contexts (Foss et al., 2010). Knowledge is not only a collective asset but also a source of individual power and competitive advantage (Yang & Ribiere, 2020).

Knowledge hiding research reflects this more nuanced view by recognizing that individuals may strategically control knowledge flows to protect status, maintain bargaining power, or avoid exploitation (Černe et al., 2014; Hernaus et al., 2019; Yang & Ribiere, 2020). From a knowledge-based view of the firm (Grant, 1996), knowledge constitutes a strategic resource; from a micro-behavioral perspective, individuals may seek to appropriate value from that resource. In academia, where intellectual contributions are directly tied to authorship credit, citations, funding success, and career progression, the incentive to manage knowledge boundaries may be particularly pronounced.

Thus, knowledge hiding can be conceptualized as a micro-level boundary management strategy within the knowledge-based organization. Rather than representing mere deviance, it may reflect rational responses to institutional incentives, evaluation systems, and perceived inequities (Abubakar et al., 2019; Butt, 2020; Butt & Ahmad, 2020; Jahanzeb et al., 2020). This perspective aligns with recent calls to examine the "dark side" of knowledge management, including counterproductive knowledge behaviors (Serenko & Bontis, 2016).

3. Knowledge Hiding in Academia: A Distinctive Context

Academia differs from corporate settings in several structural and normative dimensions. First, it operates under strong norms of openness and communalism, historically described by Merton (1973) CUDOS norms (Communalism, Universalism, Disinterestedness, Organized Skepticism). These norms promote knowledge sharing as a scientific virtue. Second, contemporary academia is increasingly performance-driven (Anderson et al., 2007). Bibliometric indicators, journal rankings, and grant success rates function as formalized evaluation mechanisms. This dual structure, i.e., normative openness versus institutional competition, creates a paradoxical environment conducive to both sharing and hiding.

Scholars and researchers may be reluctant to share preliminary ideas for fear of misuse or loss of credit, especially in competitive academic environments (Martin, 1998). Knowledge hiding in academia can be influenced by research-related norms, publication pressures, and competitive incentives, power asymmetries within research groups, and cultural and disciplinary differences in sharing norms (He et al., 2021; Hernaus et al., 2019; Yang & Ribiere, 2020; Zutshi et al., 2021). Moreover, the consequences of knowledge hiding in academia may extend beyond dyadic relationships. Because research is cumulative, concealment can delay scientific progress, reduce interdisciplinary integration, and weaken institutional trust climates (Černe et al., 2014; Černe et al., 2012). Conversely, certain forms of rationalized hiding (e.g., confidentiality due to ongoing review or ethical constraints) may be institutionally legitimate.

Thus, academic knowledge hiding must be analyzed through a multi-level lens integrating micro-motivations, meso-level relational dynamics, and macro-level institutional structures.

4. From Fragmentation to Intellectual Structure: The Need for Bibliometric Mapping

Although the theoretical richness of knowledge hiding research is evident, the literature remains dispersed across journals in knowledge management, organizational behavior, psychology, and higher education studies (Connelly et al., 2012; Hernaus et al., 2019; Xing, 2022). The rapid growth of publications since 2012 has led to conceptual diversification but also fragmentation.

Bibliometric mapping offers a systematic way to uncover the intellectual foundations, thematic clusters, and evolutionary trajectories of this research stream (Donthu et al., 2021; Zupic & Čater, 2015). For an emerging niche such as academic knowledge hiding, bibliometric analysis can reveal influential scholars and collaborative networks, thematic concentrations, and emerging frontiers. By situating academic knowledge hiding within the broader KM and organizational behavior literature, this study advances a structured understanding of how the "silent side" of knowledge processes is conceptualized and investigated. The following sections build on this theoretical foundation to empirically map the field using a systematic literature review and bibliometric analysis.

Methodology

This study adopts a systematic literature review combined with bibliometric analysis to map the intellectual and conceptual structure of research on academics' knowledge hiding behavior. The SLR ensures transparency, replicability, and methodological rigor in dataset construction (Keele, 2007; Tranfield et al., 2003), while bibliometric techniques enable quantitative science mapping of the field's evolution and structure (Donthu et al., 2021; Zupic & Čater, 2015).

The methodological procedure comprised two sequential stages. The first stage involved the systematic identification and screening of relevant publications. The second stage entailed bibliometric performance analysis and science mapping conducted using Bibliometrix and its web interface, Biblioshiny (Aria & Cuccurullo, 2017).

1. Data Collection and Search Strategy

Scopus was selected as the data source due to its extensive coverage of peer-reviewed journals across management, organizational behavior, and higher

education research. Scopus provides high-quality citation metadata and export formats compatible with bibliometric software, making it particularly suitable for science mapping studies.

To comprehensively capture research on knowledge hiding within academic contexts, the following structured query was applied to titles, abstracts, and keywords:

TITLE-ABS-KEY (("knowledge hiding" OR "knowledge concealment" OR "information hiding" OR "knowledge withholding") AND ("higher education" OR academia OR university OR "tertiary education" OR "post-secondary education"))

The search was conducted without time restriction to capture the full developmental trajectory of the field. Only peer-reviewed journal articles written in English were retained to ensure quality and comparability. The initial search conducted on December 10th, 2026 yielded 153 articles.

2. Screening and Selection Process

Following the initial retrieval of 153 records from Scopus, a rigorous multi-stage screening process was conducted. The objective was to ensure conceptual consistency with the construct of knowledge hiding as defined by Connelly et al. (2012) , while maintaining contextual specificity to academia, including research institutions and higher education institutions (HEIs).

The screening process involved title and abstract assessment, followed by full-text evaluation. To maintain analytical focus on academics' knowledge hiding behavior, several criteria was adopted to guide inclusion and exclusion decisions.

Firstly, to maintain contextual consistency, studies were excluded if they relied on mixed-sector samples in which academics were combined with respondents from non-academic organizations and results were not separately reported for the academic subsample. Including such studies would weaken contextual specificity and compromise interpretive clarity regarding academic environments. With respect to respondents, studies using students as the primary data source were excluded, as the focal interest of this study is academic staff behavior. One exception was retained: Weng et al. (2020), which surveyed PhD scholars who were fully engaged in research activities and functionally embedded in academic knowledge production processes. Given their

role within research teams and their proximity to academic work, these respondents were considered sufficiently aligned with the study's focus on academia.

Secondly, only empirical studies were retained in the final dataset. Conceptual, theoretical, or review papers were excluded to ensure that the bibliometric analysis reflects empirically grounded investigations of knowledge hiding behavior within academia contexts. This decision enhances comparability across studies and strengthens the analytical consistency of performance and science mapping results.

Thirdly, This study specifically focuses on knowledge hiding, defined as the intentional concealment of requested knowledge (Connelly et al., 2012). To preserve construct clarity and avoid conceptual contamination, strict terminological boundaries were applied. Articles were excluded if they centered primarily on:

• Knowledge concealment or knowledge withholding, given that the former frequently introduces definitional ambiguity, whereas the latter is commonly treated as a superordinate construct that includes both intentional knowledge hiding and unintentional knowledge hoarding (Kang, 2014). Because this study isolates deliberate interpersonal hiding behavior, broader framings that did not explicitly operationalize intentional knowledge hiding were excluded.

• Data hiding or information hiding in the domains of information technology, cryptography, or steganography. Although terminologically similar, these constructs concern technical protection mechanisms rather than interpersonal organizational behavior and are therefore conceptually unrelated to the present study.

This rigorous construct delimitation ensured alignment with the behavioral and interpersonal definition of knowledge hiding and prevented the inclusion of technically or metaphorically related but substantively distinct research streams.

After applying these screening criteria through title/abstract review and full-text verification, the dataset was reduced from 153 initially retrieved records to 39 empirical articles. This refined corpus forms the basis for the subsequent bibliometric performance analysis and science mapping. The overall review process was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, with the detailed screening procedure illustrated in the flow diagram shown in Figure 1.

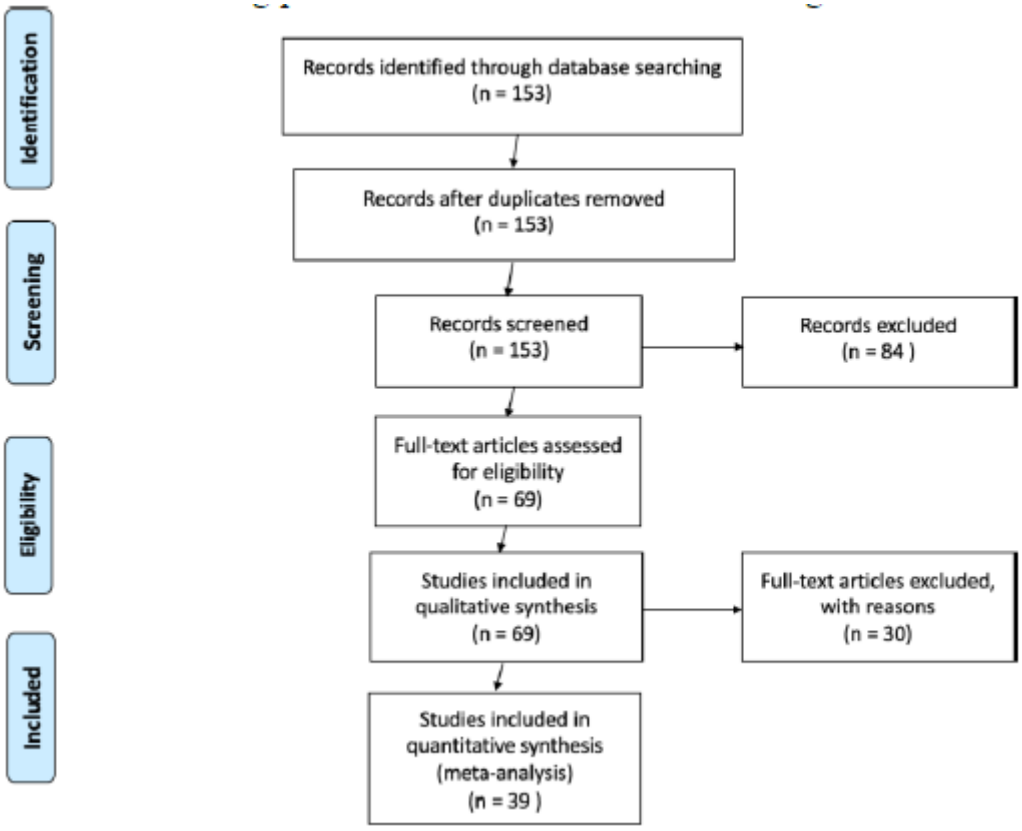


Figure 1 PRISMA framework

3. Bibliometric Analysis Procedure

Once the final dataset comprising 39 empirical articles was established after the systematic screening process, a bibliometric analysis was conducted to map the scholarly impact of research on academics' knowledge hiding behavior, intellectual structure, and thematic development. The final dataset comprised comprehensive bibliographic metadata exported from Scopus in CSV format, such as author information, institutional affiliations, countries, source titles, keywords, abstracts, and citation metrics, which were subsequently processed in Biblioshiny, the web interface of Bibliometrix R-package to enable interactive bibliometric analysis and visualization (Aria & Cuccurullo, 2017).

The bibliometric analysis proceeded along two complementary dimensions: performance analysis and science mapping, consistent with established approaches in management bibliometrics (Donthu et al., 2021; Zupic & Čater, 2015). Performance analysis assessed the productivity and scholarly impact of research on academics' knowledge hiding behavior. Specifically, the author examined annual publication trends,

leading journals, publication sources, and the most influential authors and articles (by citations). Science mapping techniques were then applied to uncover the field's intellectual and conceptual structure. Co-citation analysis identified foundational works and theoretical anchors shaping the domain (Zupic & Čater, 2015). Keyword co-occurrence (co-word) analysis was employed to detect dominant themes and research clusters (Callon et al., 1991). Thematic mapping, based on centrality and density metrics, enabled classification of themes into motor, basic, niche, and emerging categories (Cobo et al., 2011).

The present study differs from Fauzi (2023), who adopted a two-phase approach combining scientometric analysis followed by qualitative systematic review. In contrast, this study employs a reversed and more context-sensitive design. Specifically, the author first conducted a rigorous systematic literature review to identify and refine studies explicitly examining knowledge hiding within higher education contexts, and subsequently performed bibliometric analysis on this curated dataset. By sequencing the SLR prior to bibliometric mapping, the study ensures construct precision and contextual specificity, avoiding dilution from adjacent constructs (e.g., knowledge withholding, or information hiding in technical domains) and cross-sectoral samples. Consequently, the bibliometric results reflect the genuine intellectual structure of academic knowledge hiding research as a distinct subdomain. This methodological refinement enhances analytical clarity and allows for a more focused mapping of the "silent side of academia".

Results and Analysis

This section presents the findings of the bibliometric analysis based on the final dataset of 39 articles retrieved from Scopus. Following established bibliometric procedures (Donthu et al., 2021; Zupic & Čater, 2015), the results are organized into two parts: performance analysis and science mapping. The first stage examines publication productivity, citation impact, and key contributors, thereby outlining the structural characteristics of the field. The second stage moves beyond descriptive metrics to reveal the intellectual, conceptual, and thematic architecture of research on knowledge hiding

in academia. This twofold approach enables a comprehensive assessment of both the field's development trajectory and its underlying scholarly structure.

1. Performance Analysis

1.1 Annual Publication Trends

Figure 2 illustrates the annual scientific production on knowledge hiding in academia from 2019 to 2025, revealing a clear developmental trajectory of the field. During the initial phase (2019–2021), publication output remained relatively modest and fluctuating, reflecting the exploratory nature of early investigations and the limited attention given to the topic within academia. A significant shift occurred in 2022, when the number of publications increased sharply, marking the beginning of a rapid growth stage. Although a slight decline is observable in 2023, the overall upward trend quickly resumed, with 2024 and 2025 reaching the highest levels of annual output in the dataset. This sustained increase suggests that knowledge hiding in academia is gaining stronger scholarly recognition and moving beyond a peripheral extension of corporate-based knowledge hiding research. Instead, it appears to be consolidating as a context-specific and theoretically developing research domain within knowledge management and higher education studies.

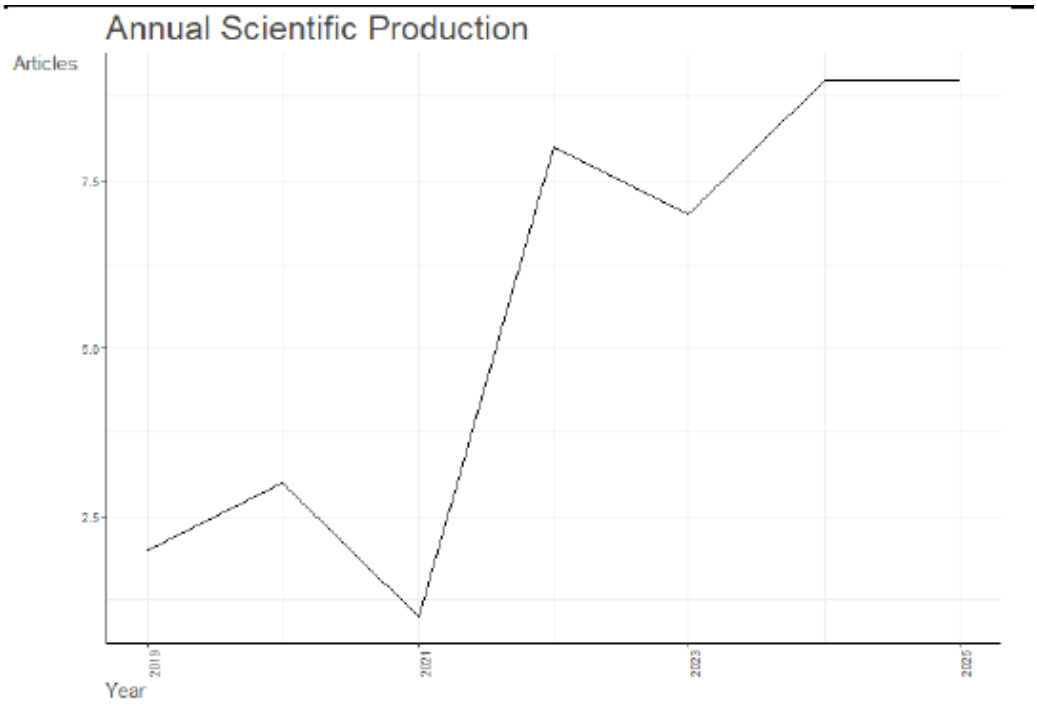


Figure 2 Yearly publications on knowledge hiding in academia

1.2 Most Frequent Publicaiton Outlets

Figure 3 presents the most relevant sources publishing research on knowledge hiding in academia. The results indicate a clear concentration of publications within knowledge management and organizational psychology outlets. Journal of Knowledge Management emerges as the leading source, contributing five articles, highlighting its central role in shaping and disseminating scholarship on knowledge behaviors. This is followed by Frontiers in Psychology andVINE Journal of Information and Knowledge Management Systems, each publishing three articles, suggesting strong engagement from both psychological and information management perspectives.

Several journals contributed two articles each, including Heliyon, International Journal of Knowledge Management Studies, Journal of Applied Research in Higher Education, Journal of Information and Knowledge Management, and Journal of the Knowledge Economy. Additionally, outlets such as Business Information Review contributed single publications, reflecting the topic's interdisciplinary diffusion.

Overall, the distribution demonstrates that research on the "silent side" of academia is primarily anchored in knowledge management and organizational behavior journals, while gradually extending into broader higher education and information systems outlets. This pattern suggests both disciplinary consolidation and increasing cross-disciplinary integration.

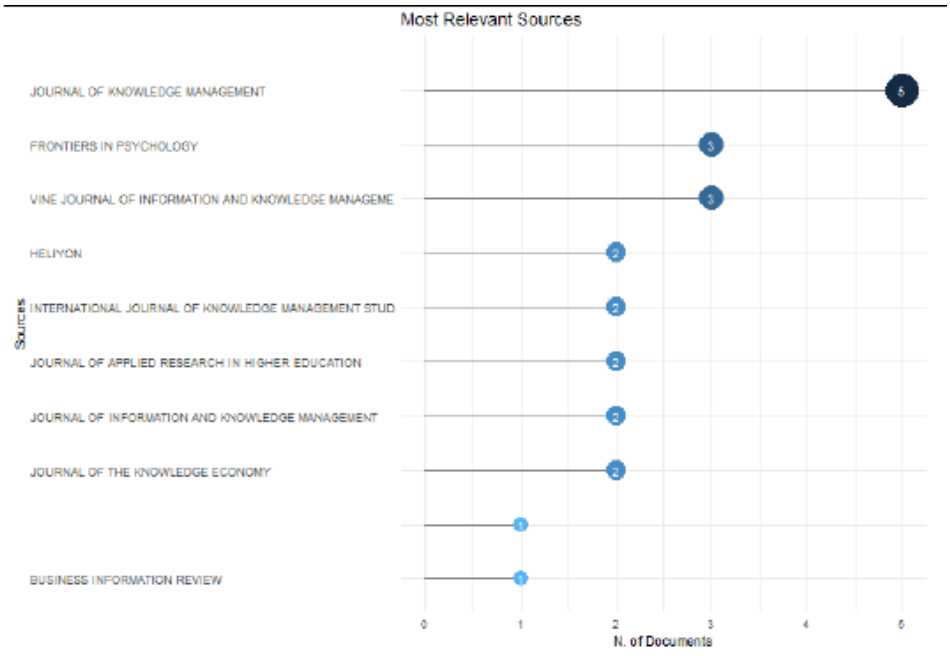


Figure 3 Most relevant sources

1.3 Most Relevant Affiliations

Figure 4 presents the most productive institutional affiliations contributing to research on knowledge hiding among academics. The results indicate a moderately dispersed institutional structure, with limited dominance by any single institution.

COMSATS University Islamabad and Government College University Faisalabad emerge as the most productive institutions, each contributing three publications. Their prominence suggests that Pakistani higher education institutions represent a significant empirical hub in advancing scholarship on knowledge hiding in academia.

A second group of institutions, each contributing two publications, includes Amity University, Fortune Institute of International Business, International Islamic University, Jahangirnagar University, Silesian University of Technology, United Arab Emirates University, Universidad de Antioquia, and Universitas Jenderal Soedirman. This distribution reflects a geographically diverse yet predominantly emerging-economy research landscape, with strong representation from South Asia, the Middle East, parts of Europe, and Latin America.

Overall, the affiliation analysis indicates that research on knowledge hiding in academia is institutionally decentralized but regionally clustered. The concentration within South Asian institutions, in particular, may reflect contextual factors such as intensified academic competition, performance pressures, and governance transformations that render knowledge hiding a salient phenomenon within these systems.

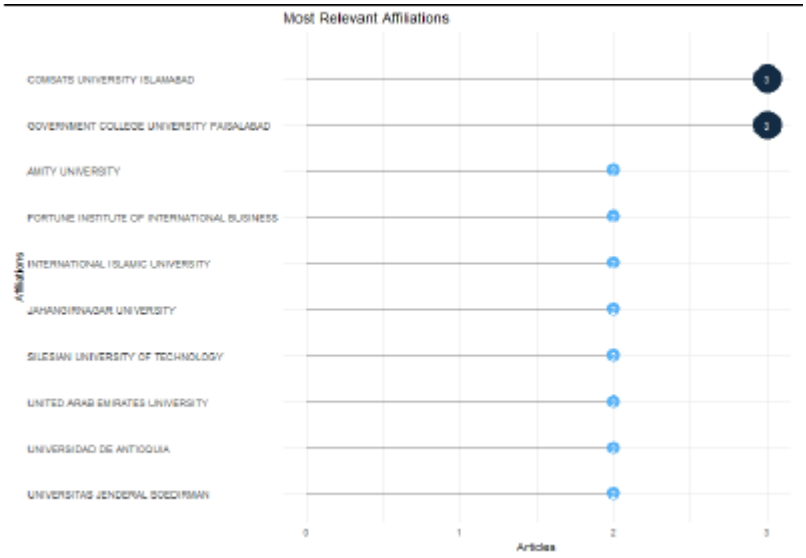


Figure 4 Most relevant affiliations

1.4 Most Locally Cited Authors

Figure 5 presents the most locally cited authors within the dataset, indicating those who exert the strongest intellectual influence on research concerning knowledge hiding in academia. Anand ranks first with 18 local citations, emerging as the most influential author within this specific citation network. He is followed by Bari (12) and Arain (11), both of whom have made substantial empirical and theoretical contributions related to workplace knowledge behaviors. Černe receives 8 local citations, while Al-Kurdi (6) and Barrick (5) also demonstrate notable influence. Additional contributors, including Abdullah, Abubakar, Agarwal, and Ahmad, each record four local citations, reflecting their continued relevance within the field.

Overall, the local citation structure suggests that research on knowledge hiding in academia is somewhat differentiated from the broader knowledge hiding literature. Rather than being dominated solely by the original conceptualizers of knowledge hiding, the field appears to draw heavily on scholars who have extended, contextualized, or empirically examined the construct in organizational and education-related settings. This indicates a gradual contextual specialization of the research stream within academia.

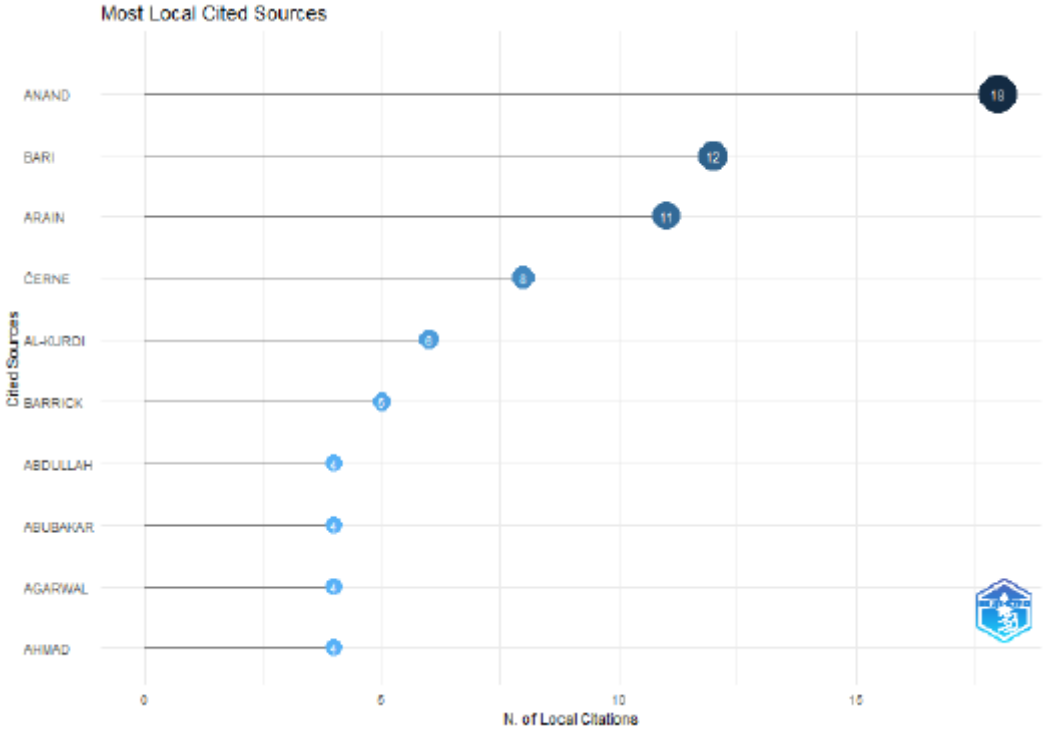


Figure 5 Leading authors by local citations

1.5 Most Influential Documents by Global Citations

Figure 6 illustrates the most globally cited documents in the dataset, highlighting those that have generated the strongest international scholarly impact. The most highly cited article is authored by Hernaus et al. (2019), titled Evasive knowledge hiding in academia: When competitive individuals are asked to collaborate, published in Journal of Knowledge Management, with 270 global citations. This study is particularly influential as it directly situates knowledge hiding within the academic context and empirically examines how individual competitiveness shapes evasive hiding behaviors under collaborative demands. Its prominence underscores the growing scholarly attention to the "silent side" of academia.

The second most cited article is authored by Malik et al. (2019) in Personality and individual differences (209 citations), followed by Weng et al. (2020) in Journal of Knowledge Management (97 citations). These works further expand the theoretical and empirical understanding of knowledge hiding, particularly in relation to leadership, interpersonal dynamics, and organizational climate.

Overall, the global citation structure reveals that while foundational conceptualizations of knowledge hiding remain influential, recent empirical investigations situated specifically in academia, particularly Hernaus et al. (2019), have become central reference points in shaping contemporary discourse.

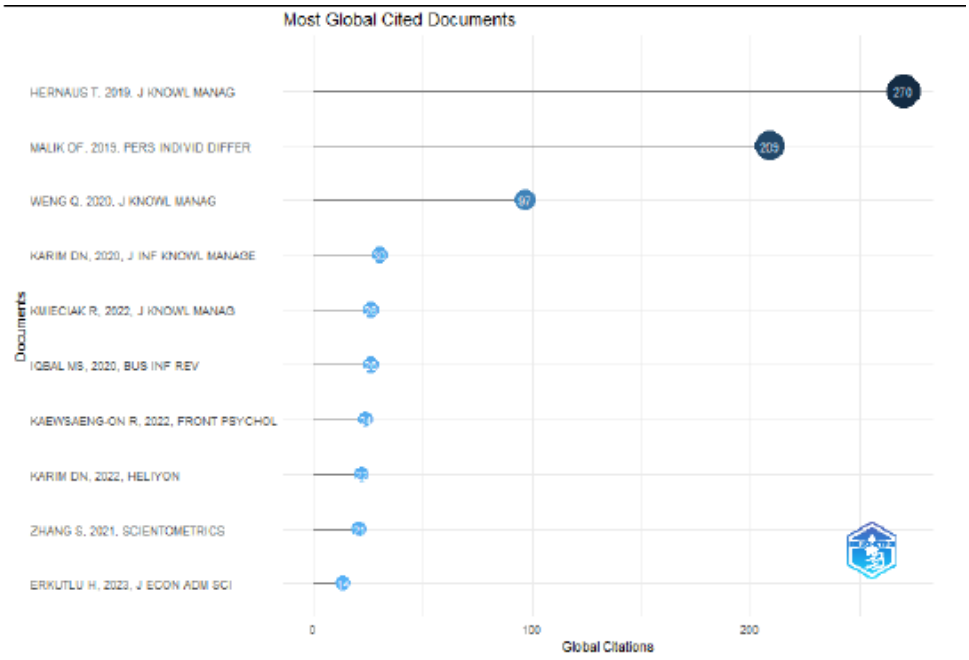


Figure 6 Most global cited documents

2. Science Mapping

While performance analysis identifies the most productive and influential contributors to the field, it does not reveal how knowledge is intellectually organized. Therefore, following established bibliometric guidelines (Donthu et al., 2021; Zupic & Čater, 2015), science mapping techniques are applied to uncover the intellectual structure (co-citation), conceptual structure (keyword co-occurrence), and thematic configuration of the domain. This second stage provides a structural interpretation of how research on knowledge hiding in academia has developed and consolidated.

2.1 Author Co-citation Analysis

Figure 7 presents the author co-citation network, revealing the intellectual structure underpinning research on knowledge hiding in higher education. The size of each node reflects citation frequency, while the links indicate how often two authors are cited together, thereby signaling theoretical proximity and shared intellectual foundations.

The network is anchored by Anand (red), who appears as one of the largest and most centrally positioned nodes. His strong co-citation ties with adjacent scholars suggest that his work forms a key theoretical bridge within the field. Closely connected to this central cluster are authors such as Aljawarneh and Ashiru, indicating a cohesive stream of research drawing on similar conceptual foundations.

A second highly prominent node is Bari (blue), who occupies a structurally influential position within another dense cluster. His connections with authors such as Bogilović, Agarwal, Abubakar, and Andersson suggest a related but somewhat distinct intellectual stream, likely grounded in organizational behavior and knowledge management perspectives. The proximity between the Anand and Bari clusters indicates partial theoretical convergence across these streams.

On the right-hand side of the network, Arain (green) forms the core of another visible cluster, connected to Černe, Aryee, Bashir, and others. The presence of works such as Exchange and Power in Social Life within this cluster suggests that social exchange theory constitutes a foundational theoretical anchor for this stream of research. This confirms that knowledge hiding scholarship in academia is deeply embedded in broader relational and power-based theoretical traditions.

Smaller, more peripheral clusters (e.g., Abdullah and Management Science Letters) indicate specialized or emerging lines of inquiry that are less integrated into the dominant intellectual core.

Overall, the co-citation structure demonstrates that research on knowledge hiding of academia is theoretically pluralistic but anchored in a relatively concentrated set of foundational scholars.

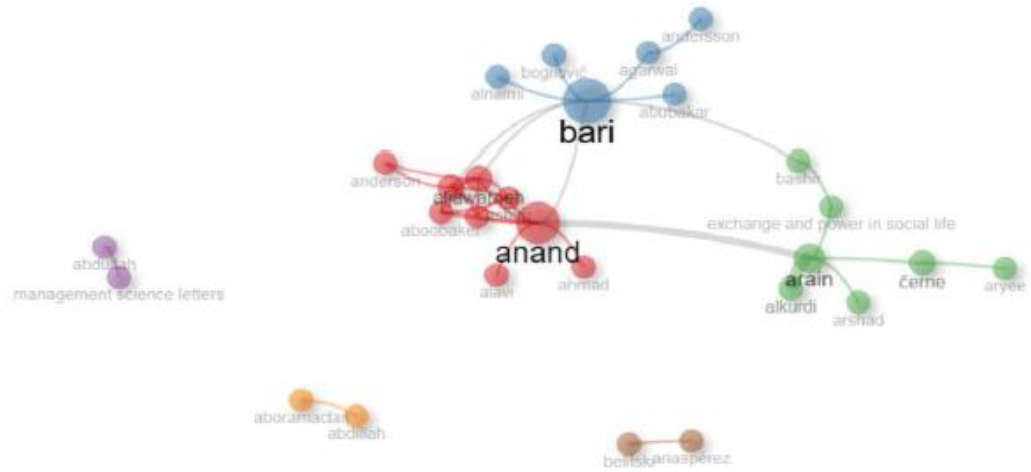


Figure 7 Author co-citation net

2.2 Keyword Co-occurrence Network

Figure 8 illustrates the keyword co-occurrence network, revealing the conceptual structure of research on knowledge hiding of academia. As expected, given the search strategy, "knowledge hiding" appears as the largest and most connected node. Beyond this methodological effect, its extensive linkages with leadership, personality, and organizational constructs indicate its function as the conceptual anchor integrating multiple research streams within the field.

One prominent cluster (red) connects knowledge hiding with "servant leadership", "higher education", "organizational support", and "creativity". This configuration suggests a dominant line of inquiry examining how leadership styles and supportive organizational climates influence knowledge behaviors and innovative outcomes within

academic institutions. The strong ties between these concepts reflect an integrated theoretical approach linking leadership theory with knowledge management perspectives.

Another cluster (blue) associates "higher education institutions" and "knowledge sharing" with personality-related constructs such as "psychopathy "and traits associated with the dark triad. This indicates a growing interest in individual differences and darker personality dimensions as antecedents of knowledge hiding in academic contexts. The positioning of this cluster slightly peripheral to the core suggests an expanding but still consolidating research trajectory.

A smaller cluster (green) highlights "workplace spirituality" in connection with "higher education institutions", reflecting an emerging focus on ethical climate and values-based frameworks. Meanwhile, a peripheral methodological cluster (purple), including terms such as "human" and "article", appears less conceptually central and likely reflects indexing or research design descriptors rather than substantive theoretical themes.

Overall, the network demonstrates that while knowledge hiding remains the conceptual nucleus, the field is progressively integrating leadership theories, personality psychology, organizational climate constructs, and higher education–specific variables. This pattern indicates increasing theoretical diversification while maintaining a coherent intellectual core.

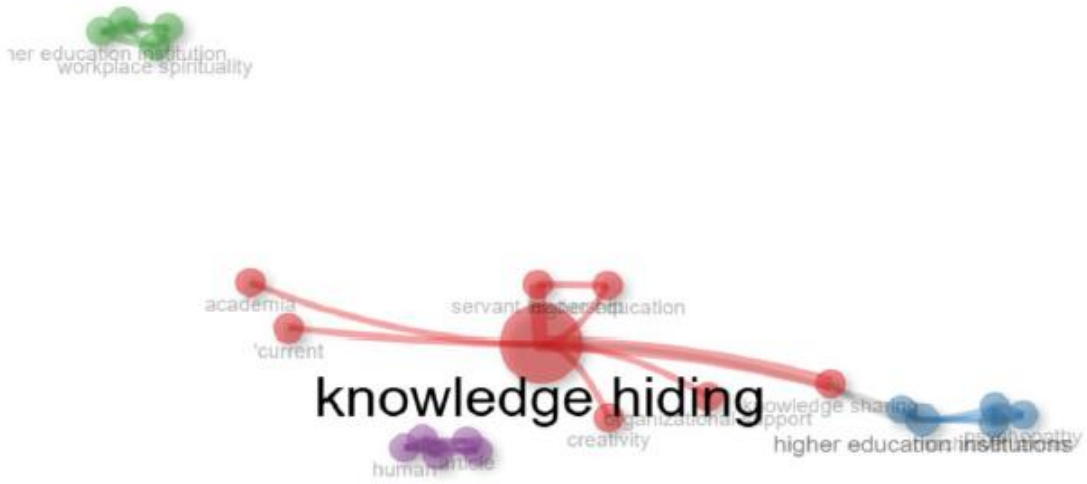


Figure 8 Keyword co-occurrence network

2.3 Thematic Mapping

Figure 9 presents the thematic map based on centrality (x-axis) and density (y-axis), enabling the classification of research themes into motor, basic, niche, and emerging/declining categories (Cobo et al., 2011). Centrality reflects the extent to which a theme is connected to other themes within the field, indicating its relevance and integrative role in the overall research structure. In contrast, density represents the internal cohesion of a theme, reflecting the degree of development and conceptual maturity of the cluster (Callon et al., 1991).

Motor themes represent mature and influential areas of research that actively shape and propel the development of the field. In the motor themes (upper right) quadrant (high centrality, high density), the cluster comprising "higher education institutions","knowledge sharing", and "abusive supervision" stands out as the most developed and structurally important theme. Its strong centrality indicates that it is well connected to other topics in the field, while its high density reflects internal conceptual cohesion. This suggests that research examining dysfunctional leadership and interpersonal dynamics within higher education institutions constitutes a driving force in shaping the discourse on knowledge hiding. A second cluster positioned near the motor quadrant center includes "workplace spirituality", "dark triad", and "higher education institution", highlighting the increasing integration of personality traits and ethical–spiritual dimensions into the explanation of knowledge-related behaviors in academia.

Basic themes are fundamental to the field but not yet fully developed internally. The basic themes (lower right) quadrant (high centrality, low density) contains the cluster of "knowledge hiding", "servant leadership", and "higher education". Its high centrality confirms that knowledge hiding remains the core organizing concept of the field. However, the comparatively lower density suggests that this line of research, while fundamental, is still evolving and diversifying conceptually. It serves as the intellectual backbone of the domain, linking various antecedents and outcomes but requiring further theoretical refinement.

Niche themes are well-developed internally but marginal to the overall field. In the niche themes (upper left) quadrant (low centrality, high density), the cluster including "article", "human", and "human experiment" appears highly developed

internally but weakly connected to the broader field. This may reflect methodological emphases or specific empirical designs that are specialized yet peripheral to the central conceptual debates.

Finally, emerging or declining themes are both weakly developed and marginal, representing either newly evolving research areas or topics losing relevance. The emerging or declining themes (lower left) quadrant (low centrality, low density) includes "academia" and "current". These themes are either nascent areas gaining initial scholarly attention or topics whose influence is diminishing. Given the relatively recent expansion of research into academic contexts, the positioning of academia likely signals an emerging trajectory, pointing to future opportunities for more context-specific theorization of knowledge hiding within higher education systems.

Overall, the thematic map indicates a field anchored in the core concept of knowledge hiding, increasingly driven by leadership and organizational climate variables, and gradually expanding toward personality-based and context-specific explanations within academia.



Figure 9 Thematic map

Discussion

This study provides a comprehensive bibliometric overview of research on knowledge hiding in academia. Integrating performance analysis and science mapping based on a systematic literature review, it offers insights into the field's evolution, concentration, and theoretical structure. Several key observations emerge from the findings.

1. From Peripheral Topic to Emerging Research Stream

The annual publication trend demonstrates that research on knowledge hiding in academia has transitioned from a nascent and exploratory phase (2019–2021) to a rapid growth stage beginning in 2022. The sharp increase in publications, followed by sustained output through 2024 and 2025, indicates that the phenomenon is no longer treated merely as an extension of corporate knowledge hiding studies. Instead, it is increasingly conceptualized as a context-sensitive issue embedded in the unique structural, relational, and performance pressures of academic institutions.

This trajectory aligns with broader transformations in higher education, including intensified research competition, performance-based evaluation systems, international rankings, and resource constraints (Hazelkorn, 2015; Musselin, 2018). Such systemic pressures may inadvertently foster competitive climates in which knowledge hiding becomes a strategic behavior. The bibliometric growth pattern therefore reflects not only academic interest but also the practical relevance of the topic in contemporary university governance.

2. Disciplinary Anchoring and Gradual Cross-Field Integration

The analysis of publication outlets confirms that the field is strongly anchored in knowledge management and organizational behavior journals. Leading outlets such as Journal of Knowledge Management have played a pivotal role in consolidating the research stream, while psychology- and higher-education-oriented journals signal interdisciplinary diffusion.

This disciplinary pattern suggests that knowledge hiding in academia is primarily framed as a behavioral and relational phenomenon rather than solely as an educational policy issue. At the same time, the gradual extension into broader higher education journals indicates an expanding recognition that knowledge behaviors among

academics have institutional-level consequences, affecting collaboration, innovation, mentoring, and organizational performance.

3. Regional Concentration and Contextual Sensitivity

The affiliation analysis reveals a geographically diverse but regionally clustered research landscape, with particularly strong representation from South Asian institutions. This concentration may reflect contextual dynamics such as high academic competition, hierarchical organizational cultures, and evolving governance systems that make knowledge hiding a salient issue.

Rather than viewing this regional clustering as a limitation, it may indicate that emerging economies provide fertile empirical contexts for examining competitive and relational tensions in academia. However, the field would benefit from broader comparative studies across Western, Asian, and other global higher education systems to enhance contextual generalizability and theoretical robustness.

4. Intellectual and Conceptual Consolidation

The author co-citation analysis indicates that the field is theoretically pluralistic but anchored in a relatively concentrated intellectual core. Simultaneously, the keyword co-occurrence and thematic analyses reveal increasing diversification. Leadership styles (e.g., abusive and servant leadership), personality traits (e.g., dark triad characteristics), and ethical or spiritual dimensions are emerging as important explanatory mechanisms. This suggests a shift toward multi-level theorization that integrates individual, interpersonal, and institutional perspectives.

5. Field Maturity and Developmental Stage

Overall, the bibliometric patterns suggest that research on knowledge hiding in academia is in an early-to-intermediate stage of maturity. The field demonstrates increasing publication momentum, identifiable intellectual clusters, and expanding thematic breadth. However, theoretical integration across streams remains partial, and context-specific theorization of academic systems is still developing.

Implications for Theory and Practice

Building on these observations, the findings not only delineate the current structure and developmental stage of the field but also point to critical gaps and

opportunities for advancement. In particular, the coexistence of a consolidating conceptual core with expanding yet fragmented thematic streams underscores the need for deeper theoretical integration and more context-sensitive frameworks. These insights provide the foundation for deriving implications for both theory and practice.

1. Theoretical Implications

This bibliometric synthesis offers several important theoretical contributions to the emerging domain of knowledge hiding in academia.

First, the findings indicate that the field is transitioning from conceptual transfer to contextual theorization. Early research largely borrowed frameworks from corporate knowledge hiding literature. However, the science mapping results demonstrate a growing effort to embed the construct within the institutional logic of academic settings. This shift suggests the need to theorize knowledge hiding not merely as an interpersonal workplace behavior, but as a phenomenon shaped by academic norms such as collegiality, disciplinary silos, tenure systems, publication pressures, and competitive funding structures.

Second, the prominence of leadership styles (e.g., abusive supervision, servant leadership) and personality traits (e.g., dark triad characteristics) highlights the emergence of multi-level explanatory models. Future theoretical development should explicitly integrate Individual-level antecedents (personality traits, competitiveness, psychological insecurity), interpersonal mechanisms (trust, reciprocity norms, perceived fairness), and institutional-level structures (governance models, ranking systems, performance evaluation regimes). Such integration would move the field beyond fragmented antecedent–outcome studies toward more comprehensive, systems-based frameworks.

Third, the regional clustering observed in the affiliation analysis raises important theoretical questions regarding contextual boundary conditions. Academic competition, hierarchical structures, and governance reforms vary significantly across national higher education systems. Cross-cultural comparative research would therefore enhance theoretical robustness by identifying whether knowledge hiding operates as a universal behavioral response or as a context-contingent strategy.

Fourth, the thematic map suggests that while knowledge hiding remains the core organizing concept, the construct itself may require further conceptual refinement within academia. For example, future research might differentiate between strategic, defensive, politically motivated, and resource-protection forms of knowledge hiding in academic contexts. This differentiation would support construct clarity and theoretical maturation.

Collectively, these directions signal that the field is ready to move from exploratory empirical expansion toward deeper theoretical consolidation.

2. Practical Implications

The findings carry significant implications for university governance, leadership development, and institutional policy design.

First, the strong linkage between knowledge hiding and leadership variables suggests that managerial behavior within academia plays a central role in shaping knowledge exchange norms. Leadership development programs should therefore prioritize ethical conduct, psychological safety, and fairness perceptions. Reducing supervisory hostility and increasing supportive leadership practices may directly mitigate hiding behaviors.

Second, the concentration of research around performance pressures and competitive dynamics implies that institutional incentive systems may inadvertently encourage knowledge hiding. Universities and research institutions should critically evaluate evaluation metrics that excessively emphasize individual publication counts, citation indices, or grant acquisition without rewarding collaborative contributions. Balanced performance systems that recognize team-based research, co-authorship, and mentoring activities may foster more open knowledge climates.

Third, the integration of personality-related constructs indicates that knowledge hiding is not solely structurally induced but also psychologically mediated. Institutions may consider implementing training programs that cultivate trust-building skills, conflict management competencies, and collaborative mindsets among faculty members.

Finally, the practical relevance of these findings becomes more evident when considered alongside the documented consequences of knowledge hiding. Prior research shows that knowledge hiding reduces job satisfaction (Offergelt et al., 2019), productivity (Butt, 2019a), task performance (Singh, 2019), and innovation capacity (Cai &

Wen, 2018; Černe et al., 2017). In line with the present bibliometric results, which highlight leadership, interpersonal dynamics, and organizational climate as dominant research themes, these outcomes suggest that managerial practices and institutional environments in higher education play a pivotal role in shaping not only knowledge behaviors but also broader performance outcomes. Practically, this implies that efforts to mitigate knowledge hiding - through supportive leadership, fair evaluation systems, and trust-based academic cultures - are likely to yield tangible benefits in terms of faculty well-being, research productivity, and institutional innovation.

Limitations and Future Research Avenues

Despite its contributions, this study is subject to several limitations that simultaneously open avenues for future research.

First, the dataset was derived exclusively from Scopus-indexed publications. Although Scopus offers extensive interdisciplinary coverage, relevant studies indexed in Web of Science, Google Scholar, or regional databases may not have been captured. Consequently, the intellectual and thematic structures identified reflect the Scopus-indexed corpus rather than the entirety of global scholarship. Future bibliometric studies could adopt multi-database approaches to enhance comprehensiveness and validate the stability of network configurations.

Second, the relatively small sample size (39 documents) reflects the emerging nature of research on knowledge hiding in academia. While suitable for exploratory bibliometric mapping, the limited corpus may influence network density and cluster formation. As publication output continues to grow, future analyses should reassess the field's intellectual and thematic structure to determine whether clearer subfields, stronger theoretical consolidation, or new research streams emerge.

Third, citation-based techniques inherently privilege earlier publications and highly visible journals. Recently published studies, particularly those from 2024 and 2025, may not yet have accumulated sufficient citations to be prominently represented in co-citation networks. Longitudinal bibliometric analyses would therefore be valuable in tracking how influence patterns evolve over time and whether emerging scholars reshape the intellectual core of the domain.

Fourth, bibliometric methods identify structural relationships among authors, keywords, and documents but do not evaluate theoretical rigor, methodological quality, or empirical robustness at the individual study level. Future research could complement bibliometric mapping with meta-analyses to assess effect sizes, theoretical consistency, and research design sophistication.

Beyond methodological considerations, several substantive research opportunities emerge.

The science mapping results suggest the need for stronger multi-level theorization, integrating individual traits, leadership behaviors, and institutional governance systems within unified explanatory frameworks. Future studies should move beyond isolated antecedent-outcome models toward more comprehensive, contextually embedded designs.

Moreover, the regional clustering of research highlights the importance of cross-cultural comparative studies. Differences in academic competition, governance structures, tenure systems, and funding models across higher education systems may shape knowledge hiding behaviors in distinct ways. Comparative research would enhance theoretical generalizability and clarify contextual boundary conditions.

Additionally, the construct itself warrants further refinement in academic contexts. Future research could differentiate between strategic, defensive, politically motivated, and resource-protection forms of knowledge hiding within universities. Such conceptual clarification would strengthen construct validity and theoretical precision.

Finally, given the increasing performance pressures and digital transformation happening within academia, future studies may explore how hybrid work environments, interdisciplinary collaborations, and artificial intelligence tools influence knowledge hiding and sharing dynamics.

Taken together, addressing these methodological and substantive directions will contribute to the maturation of research on knowledge hiding in academia and support its evolution into a theoretically integrated and contextually grounded field.

Conclusion

This study advances understanding of the "silent side of academia" by systematically mapping the intellectual and conceptual landscape of knowledge hiding

research in higher education. The findings reveal a field that is gaining momentum, anchored in established knowledge management and organizational behavior theories, yet increasingly evolving toward context-specific explanations shaped by academic norms and institutional pressures. By integrating systematic literature review with bibliometric analysis, this study not only clarifies the structure and development of the domain but also highlights critical gaps and future directions. As higher education systems continue to face intensifying competition and performance demands, addressing knowledge hiding becomes essential for fostering collaborative, innovative, and sustainable academic environments.

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Digital Leadership of Educational Administrators in the 21st Century

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Abstract

Digital transformation has significantly reshaped educational management in the twenty-first century, requiring educational administrators to develop digital leadership competencies. This study aims to (1) synthesize the concept of digital leadership, (2) identify key dimensions of digital leadership among educational administrators, and (3) propose a conceptual framework explaining the relationship between digital leadership and educational management effectiveness. The study employed a documentary research approach by analyzing and synthesizing over 50 scholarly sources from international databases, including Scopus and Web of Science. Content analysis was used to identify major themes and relationships. The findings reveal that digital leadership consists of five key dimensions: digital vision, digital communication, digital professionalism, digital learning culture, and digital literacy. Furthermore, the study proposes that digital leadership functions as an independent variable influencing educational management effectiveness through the mediating role of digital learning culture. The results provide a theoretical foundation for future empirical research and practical guidance for developing digital leadership competencies in educational institutions.

Keywords: digital leadership, educational administration, technology leadership, digital transformation, school leadership

Introduction

The rapid advancement of digital technologies has transformed nearly every aspect of modern society, including the way organizations operate and the manner in

which knowledge is created and disseminated. In the twenty-first century, digital technologies such as cloud computing, artificial intelligence, big data, and online learning platforms have reshaped educational systems worldwide. These developments have significantly influenced how educational institutions manage information, support teaching and learning, and develop innovative learning environments.

Educational institutions are increasingly expected to prepare students with competencies relevant to the digital era, including critical thinking, collaboration, digital literacy, and lifelong learning skills. To achieve these goals, schools must integrate digital technologies into both administrative processes and instructional practices. This transformation requires educational leaders who possess not only managerial competence but also the ability to guide technological change and foster innovation within their institutions.

Digital leadership has therefore emerged as a critical competency for educational administrators. According to Flanagan and Jacobsen (2003), educational leaders play a vital role in facilitating the integration of technology into teaching and learning processes. Their study highlighted that school principals who demonstrate strong technology leadership are more likely to encourage teachers to adopt digital tools in instructional practices.

Similarly, Anderson and Dexter (2005) found that leadership support is one of the most significant factors influencing successful technology implementation in schools. Administrators who provide clear technological vision, professional development opportunities, and organizational support can significantly enhance technology integration in educational environments.

In addition, Sheninger (2014) emphasized that digital leadership involves the ability of leaders to leverage digital tools to enhance communication, improve collaboration, and foster innovation within organizations. Digital leaders are expected to model technology use, create digital learning cultures, and empower teachers and students to utilize digital resources effectively.

Within the context of educational administration, digital leadership has become increasingly important as educational institutions face challenges associated with technological change, globalization, and the need for innovation in teaching and learning. Educational

administrators must therefore develop new leadership approaches that emphasize flexibility, collaboration, and digital competency.

In many countries, educational policies now emphasize the importance of digital transformation in education. Organizations such as UNESCO (2020) and OECD (2019) have highlighted the role of digital technologies in improving educational access, quality, and equity. These policy frameworks underscore the necessity for educational leaders to possess digital leadership competencies that enable them to guide schools through digital transformation.

Despite the increasing importance of digital leadership in education, many studies have primarily focused on technology integration or leadership practices in isolation. There remains a lack of comprehensive frameworks that integrate digital leadership competencies with organizational outcomes in educational contexts, particularly in developing countries such as Thailand. Furthermore, limited research has examined the mediating role of organizational factors, such as digital learning culture, in linking leadership practices to educational effectiveness. Therefore, this study addresses this gap by synthesizing existing literature and proposing an integrated conceptual framework that explains the relationships among digital leadership, digital learning culture, and educational management effectiveness.

Therefore, understanding the concept, components, and implications of digital leadership is essential for improving educational management in the digital era. This article aims to contribute to the academic discourse on digital leadership by synthesizing relevant literature and proposing a conceptual framework that explains how digital leadership influences educational effectiveness.

Objectives of the Article

This academic article aims to achieve the following objectives:

1. synthesize the concept of digital leadership.
2. identify key dimensions of digital leadership among educational administrators.
3. propose a conceptual framework explaining the relationship between digital leadership and educational management effectiveness.

Literature Review

Digital Transformation and Educational Leadership in the 21st Century

The rapid advancement of digital technologies has fundamentally transformed modern societies and organizations. Digital technologies such as cloud computing, artificial intelligence, big data analytics, and mobile learning platforms have reshaped communication, knowledge creation, and information exchange across multiple sectors. The education sector is no exception, as schools and universities increasingly adopt digital technologies to enhance teaching, learning, and administrative processes. Consequently, educational leadership has undergone significant transformation in response to the growing importance of digital technologies in educational environments.

Digital transformation refers to the process by which organizations integrate digital technologies into all aspects of their operations in order to improve efficiency, innovation, and value creation (Dwivedi et al., 2021). In educational institutions, digital transformation involves the adoption of digital learning platforms, data-driven decision-making systems, online collaboration tools, and digital assessment methods. These technological changes require educational administrators who possess the competencies necessary to guide institutions through technological and organizational change.

Educational leadership in the digital age therefore requires new forms of leadership that combine traditional managerial competencies with digital expertise. According to Sheninger (2014), digital leadership represents a leadership approach that leverages technology to enhance communication, collaboration, and learning within educational organizations. Digital leaders are responsible not only for managing technological infrastructure but also for fostering innovation and supporting teachers and students in the effective use of digital tools.

The importance of digital leadership has become particularly evident during global disruptions such as the COVID-19 pandemic, which forced educational institutions worldwide to transition rapidly to online learning environments. Research by Bond et al. (2021) indicated that schools with strong digital leadership were better prepared to maintain instructional continuity during periods of educational disruption. Leaders who possessed digital competencies were able to coordinate remote learning systems,

support teacher training in digital pedagogy, and communicate effectively with stakeholders during crisis situations.

Furthermore, international organizations such as UNESCO (2020) and OECD (2019) have emphasized the importance of digital transformation in education as a key strategy for improving educational access, equity, and quality. These organizations have highlighted the need for educational leaders who can guide digital transformation processes and ensure that digital technologies are used effectively to support learning outcomes.

As educational systems continue to evolve in response to technological innovation, the role of educational leaders has expanded beyond traditional administrative responsibilities. Educational administrators must now act as strategic leaders who guide institutions through complex digital transformation processes while maintaining educational quality and organizational stability.

Conceptual Foundations of Digital Leadership

The concept of digital leadership has its roots in earlier research on technology leadership and transformational leadership within educational organizations. Early studies on technology leadership emphasized the role of school administrators in facilitating the adoption and integration of technological tools in educational settings.

Flanagan and Jacobsen (2003) were among the first scholars to emphasize the importance of technology leadership in schools. Their research demonstrated that school principals play a crucial role in supporting the integration of technology into instructional practices. They argued that effective technology leadership requires administrators to establish clear technological visions, allocate resources for digital infrastructure, and support teacher professional development.

Anderson and Dexter (2005) conducted one of the most influential empirical studies examining technology leadership in educational institutions. Their research found that leadership support was the most significant factor influencing successful technology integration in schools. Schools with strong leadership commitment to technology adoption were more likely to develop sustainable technology integration practices.

As digital technologies became more complex and widely integrated into organizational processes, the concept of digital leadership emerged as a broader framework that extends beyond technology management. Wilson (2013) described digital leadership as a paradigm shift in leadership practices that integrates technological innovation with strategic organizational management.

Digital leadership involves multiple competencies, including technological knowledge, strategic planning, organizational communication, and innovation management. Leaders must be able to understand technological trends, evaluate digital tools, and align technological initiatives with institutional goals.

Sheninger (2014) further expanded the concept of digital leadership by emphasizing the role of leaders in creating digitally connected learning environments. According to Sheninger, digital leaders must leverage social media platforms, collaborative technologies, and digital communication channels to enhance transparency, collaboration, and engagement within educational communities.

In addition, digital leadership incorporates elements of transformational leadership, which focuses on inspiring followers to embrace change and pursue collective goals (Bass & Riggio, 2006). Digital leaders must motivate teachers and staff to adopt new technological practices and participate actively in organizational innovation processes.

Thus, digital leadership represents an interdisciplinary concept that integrates principles from educational leadership, organizational change theory, and digital technology management.

Technology Leadership and Technology Integration in Schools

Technology integration has been widely studied in educational research, particularly in relation to the role of school leadership. Technology integration refers to the effective incorporation of digital technologies into teaching and learning processes in ways that enhance educational outcomes.

Research has consistently shown that leadership plays a crucial role in shaping technology integration practices in educational institutions. Dexter (2011) emphasized that school administrators influence technology integration through policy development, resource allocation, and the establishment of supportive organizational cultures.

School leaders who actively promote technology integration are more likely to create environments in which teachers feel supported in experimenting with digital tools and innovative instructional strategies. When administrators provide professional development opportunities, technical support, and clear expectations regarding technology use, teachers are more likely to adopt digital pedagogies.

Ertmer and Ottenbreit-Leftwich (2013) identified several factors influencing teachers' technology integration practices, including leadership support, access to technological resources, and teacher beliefs about technology. Their research indicated that leadership support plays a critical role in shaping teachers' attitudes toward technology adoption.

Furthermore, distributed leadership theory provides valuable insights into how leadership responsibilities related to technology integration can be shared among multiple stakeholders. Harris (2015) argued that effective leadership involves collaboration among administrators, teachers, and technology specialists.

In digitally connected educational environments, technology integration requires collective efforts among various members of the educational community. Educational leaders must therefore create collaborative structures that enable teachers to share knowledge, exchange best practices, and engage in professional learning communities.

Technology leadership is therefore a critical component of digital leadership in educational organizations.

Digital Literacy and Professional Competencies of Educational Leaders

Digital literacy represents another fundamental component of digital leadership. Digital literacy refers to the ability to effectively use digital technologies to access, analyze, create, and communicate information in digital environments (Martin & Grudziecki, 2006).

In educational contexts, digital literacy extends beyond technical skills to include critical thinking, information evaluation, ethical awareness, and digital citizenship. Educational leaders must possess these competencies in order to guide teachers and students in responsible and effective technology use.

The Technological Pedagogical Content Knowledge (TPACK) framework developed by Mishra and Koehler (2006) provides a useful theoretical model for understanding the relationship between technology, pedagogy, and subject knowledge. Although the TPACK framework primarily focuses on teacher competencies, it also has important implications for educational leadership.

Administrators who understand the relationships between technology, pedagogy, and content knowledge are better equipped to support teachers in designing innovative learning experiences. Such leaders can guide professional development initiatives that help teachers integrate digital technologies into their instructional practices.

Digital literacy also plays an important role in supporting data-driven decision-making within educational institutions. Modern educational systems increasingly rely on digital data management systems that provide administrators with access to student performance data, attendance records, and instructional analytics.

Leaders who possess strong digital literacy skills can analyze these data sources to inform strategic planning, identify areas for improvement, and develop evidence-based educational policies.

Furthermore, digital literacy contributes to ethical and responsible technology use. Educational leaders must ensure that digital technologies are used in ways that protect student privacy, promote digital citizenship, and maintain academic integrity.

Thus, digital literacy is a foundational competency that enables educational leaders to navigate complex digital ecosystems and guide educational institutions toward responsible and effective technology use.

Digital Innovation and Organizational Culture in Education

Organizational culture plays a critical role in shaping the success of digital transformation initiatives in educational institutions. Organizational culture refers to the shared values, beliefs, and practices that influence how members of an organization interact and perform their roles.

Fullan (2014) emphasized that successful educational reform requires leaders who can cultivate cultures that support collaboration, continuous learning, and innovation.

In the context of digital transformation, educational leaders must create environments that encourage experimentation with new technologies and pedagogical approaches.

Avidov-Ungar and Eshet-Alkalai (2017) argued that digital innovation requires organizations to adopt cultures that support knowledge sharing, collaboration, and professional growth. Educational leaders must therefore promote professional learning communities in which teachers can exchange ideas and explore innovative teaching strategies.

Research has also shown that institutional culture significantly influences teachers' willingness to adopt new technologies. Schools that foster open communication, trust, and collaboration are more likely to successfully implement technology integration initiatives.

Educational leaders must therefore play an active role in shaping organizational cultures that support digital innovation and continuous professional development.

Dimensions of Digital Leadership in Educational Administration

Based on the synthesis of previous literature, several key dimensions of digital leadership can be identified. These dimensions represent the competencies required for educational administrators to effectively lead digital transformation initiatives.

The first dimension is digital vision, which refers to the ability of leaders to establish strategic directions for technology integration within educational institutions. Leaders who possess digital vision can anticipate emerging technological trends and align institutional strategies with future educational needs.

The second dimension is digital communication, which involves the use of digital technologies to facilitate communication and collaboration among stakeholders. Digital leaders utilize communication platforms, social media, and online collaboration tools to engage teachers, students, and community members.

The third dimension is digital professionalism, which refers to the ethical and responsible use of digital technologies in professional contexts. Educational leaders must demonstrate professional conduct in digital environments and promote responsible technology use within their institutions.

The fourth dimension is digital learning culture, which refers to the organizational environment that supports experimentation, innovation, and collaborative learning. Leaders who promote digital learning cultures encourage teachers to explore new pedagogical approaches and share best practices with colleagues.

Finally, digital literacy represents the foundational competency that enables leaders to effectively use digital technologies in decision-making processes, strategic planning, and instructional leadership.

Together, these five dimensions form a comprehensive framework for understanding digital leadership in educational administration.

From the review, it can be concluded that digital leadership is a multidimensional construct comprising five key components: digital vision, digital communication, digital professionalism, digital learning culture, and digital literacy. Previous studies consistently indicate that these dimensions influence technology integration, teacher professional development, and organizational innovation.

Furthermore, the literature suggests that digital learning culture plays a crucial role as an organizational mechanism that enables the effective implementation of digital leadership practices. Based on this synthesis, this study proposes that digital leadership functions as an independent variable influencing educational management effectiveness, with digital learning culture acting as a mediating variable. This relationship forms the basis of the conceptual framework presented in this study.

Table 1 Synthesis of Previous Research on Digital Leadership (20 Studies)

Table 1 : Synthesis of Previous Research on Digital Leadership (20 Studies)

Author	Year	Focus	Methodology	Key Findings
Flanagan & Jacobsen	2003	Technology leadership	Survey	Leadership influences technology adoption
Anderson & Dexter	2005	ICT leadership	Quantitative	Leadership support predicts ICT use
Martin & Grudziecki	2006	Digital literacy	Conceptual	Digital literacy is essential skill
Mishra & Koehler	2006	TPACK	Conceptual	Integration of tech, pedagogy, content
Dexter	2011	Technology leadership	Mixed	Leaders shape school tech culture
Chang	2012	Digital leadership	Survey	Vision affects technology adoption
Wilson	2013	Digital leadership	Conceptual	Leadership paradigm shift
Sheninger	2014	Digital leadership	Case study	Leaders promote digital innovation
Fullan	2014	Educational change	Conceptual	Leadership drives transformation
Harris	2015	Distributed leadership	Qualitative	Collaboration enhances innovation
Zhu	2016	Digital mastery	Case	Digital strategy improves performance
Avidov-Ungar	2017	Digital innovation	Mixed	Technology enables innovation
Chamchoy	2017	Digital leadership	Conceptual	5 dimensions proposed
Thannimalai & Raman	2018	Technology leadership	SEM	Leadership influences teacher ICT use
ISTE	2018	Education leadership	Framework	Digital leadership standards
OECD	2019	Digital education	Policy	Schools must transform digitally
Ertmer	2020	Technology integration	Mixed	Teacher beliefs influence integration
UNESCO	2020	ICT in education	Policy	Digital transformation essential
Dwivedi et al.	2021	Digital transformation	Review	Leadership critical for transformation
Bond et al.	2021	Digital learning	Review	Digital leadership supports innovation

The synthesis of 20 previous studies presented in Table 1 demonstrates that leadership plays a critical role in technology integration and educational innovation.

Across different research contexts, leadership variables consistently influence teachers' technology use, organizational culture, and institutional performance.

Based on this synthesis, this study identifies digital leadership as a key independent variable that encompasses five core dimensions. Additionally, the literature highlights that organizational culture-particularly digital learning culture-acts as a mechanism through which leadership influences outcomes. Therefore, this study proposes that digital leadership affects educational management effectiveness indirectly through digital learning culture, which serves as a mediating variable in the conceptual framework.

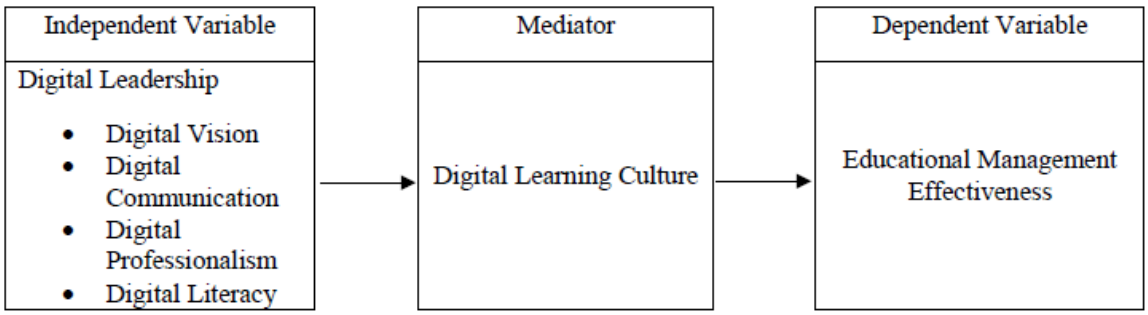
Digital Leadership Model (Five Dimensions)

Digital Leadership Dimensions: 1) Digital Vision 2) Digital Communication 3) Digital Professionalism 4) Digital Learning Culture 5) Digital Literacy.



Picture 1 Digital Leadership Model (Five Dimensions)

Conceptual Framework



Methodology

This study employed a documentary research design involving the systematic analysis of academic literature related to digital leadership in educational administration. Data were collected from international academic databases, including Scopus, Web of Science, ERIC, and ScienceDirect.

The selection criteria included:

1. Peer-reviewed publications
2. Studies related to digital leadership or technology leadership
3. Publications between 2000 and 2024

A total of approximately 70 studies were initially reviewed, and 50 relevant studies were selected for in-depth analysis.

Data were analyzed using content analysis to identify recurring themes, patterns, and relationships among variables. The analysis focused on identifying key components of digital leadership and their relationship to educational management effectiveness.

Discussion

The findings of this study highlight the increasingly critical role of digital leadership in shaping the effectiveness of educational management in the twenty-first century. As digital technologies continue to transform educational environments, school administrators must develop leadership competencies that support the integration of technological innovation into teaching, learning, and institutional management. Consistent with Anderson and Dexter (2005), leadership support is one of the most influential factors affecting successful technology integration in schools. Administrators who demonstrate strong digital leadership capabilities are more likely to establish

strategic visions for technology use, allocate resources effectively, and create supportive conditions that enable teachers to adopt digital tools in their instructional practices.

Another important finding of this study is the mediating role of digital learning culture in the relationship between digital leadership and educational management effectiveness. Organizational culture has long been recognized as a fundamental factor influencing educational innovation (Fullan, 2014). When school leaders actively cultivate a culture that values experimentation, collaboration, and continuous professional development, teachers are more likely to embrace digital technologies as part of their pedagogical practices. Dexter (2011) emphasized that technology integration is not simply a matter of providing technological infrastructure but requires leadership that encourages collaborative learning environments and supports professional growth among educators.

The synthesis of previous research also indicates that digital leadership extends beyond technological competence and involves broader transformational leadership characteristics. Transformational leadership theory suggests that effective leaders inspire followers to achieve collective goals and embrace organizational change (Bass & Riggio, 2006). In the context of digital transformation, educational leaders must act as change agents who encourage innovation and guide institutions through complex technological transitions. Research by Avidov-Ungar and Eshet-Alkalai (2017) suggests that school leaders who demonstrate strong digital leadership skills can significantly influence teachers' willingness to adopt new digital pedagogies.

Furthermore, the five dimensions of digital leadership identified in this study-digital vision, digital communication, digital professionalism, digital learning culture, and digital literacy-provide a comprehensive framework for understanding the competencies required of educational administrators in the digital age. These dimensions align with global educational technology leadership frameworks such as the ISTE Standards for Education Leaders (ISTE, 2018). According to these standards, effective educational leaders must promote visionary leadership, foster professional growth, and build digital-age learning cultures within educational institutions.

Digital vision, in particular, plays a fundamental role in guiding the long-term technological development of educational institutions. Leaders who articulate clear

digital strategies can align institutional goals with emerging technological opportunities. According to Zhu (2016), organizations that develop coherent digital strategies are more likely to achieve sustainable innovation and improved organizational performance. Within educational institutions, digital vision enables administrators to establish clear priorities for technology integration, professional development, and digital infrastructure development.

Digital communication also represents a critical dimension of leadership in digitally connected educational environments. Advances in communication technologies have transformed the ways in which leaders interact with teachers, students, parents, and stakeholders. Sheninger (2014) argues that digital leaders must leverage social media platforms, collaborative tools, and digital communication channels to enhance transparency and engagement within educational communities. Effective communication strategies help leaders build trust, share information efficiently, and foster collaborative relationships among stakeholders.

Finally, digital literacy and digital professionalism are essential competencies for educational leaders who must navigate complex technological ecosystems. Martin and Grudziecki (2006) emphasize that digital literacy involves not only technical skills but also critical thinking, ethical awareness, and responsible technology use. Educational administrators must therefore model ethical and responsible digital behavior while supporting teachers and students in developing digital citizenship skills. By demonstrating professional digital practices, school leaders can establish norms that promote responsible and effective technology use throughout the institution.

Implications for Policy and Practice

The findings of this study have important implications for educational policy and leadership practice. First, policymakers should prioritize the development of digital leadership competencies among educational administrators. As digital transformation continues to reshape educational systems, leadership development programs must include training in digital strategy, technology integration, and data-informed decision-making. National and regional education authorities should design professional

development programs that equip school leaders with the knowledge and skills necessary to guide digital transformation within their institutions.

Second, educational institutions should establish professional learning communities that support continuous digital skill development among teachers and administrators. Collaborative learning environments enable educators to share best practices, experiment with innovative teaching methods, and develop new pedagogical approaches using digital technologies. According to Ertmer and Ottenbreit-Leftwich (2013), sustained professional learning opportunities are essential for helping teachers integrate technology effectively into instructional practices.

Third, educational leaders should focus on developing organizational cultures that support innovation and experimentation. Institutions that encourage risk-taking, collaboration, and reflective practice are more likely to succeed in implementing digital transformation initiatives. Fullan (2014) emphasizes that sustainable educational reform requires leadership that fosters collective responsibility and shared vision among stakeholders.

Finally, educational policies should emphasize equitable access to digital resources and technological infrastructure. While digital leadership is essential, the successful implementation of digital transformation initiatives also depends on adequate technological infrastructure, technical support, and access to digital learning tools. Governments and educational organizations must therefore invest in technological infrastructure to ensure that schools can effectively implement digital learning initiatives.

Limitations and Future Research

Despite its contributions, this study has several limitations that should be acknowledged. First, the study employed a documentary research approach that relied on the synthesis of existing literature rather than empirical data collection. While this approach allowed for a comprehensive review of current knowledge on digital leadership, it does not provide direct empirical evidence regarding the relationships between digital leadership, digital learning culture, and educational management effectiveness.

Second, the conceptual framework proposed in this study has not yet been empirically tested. Future research should conduct quantitative or mixed-method

studies to examine the relationships among the proposed variables. Structural equation modeling (SEM) or path analysis could be used to test the mediating role of digital learning culture between digital leadership and educational management effectiveness.

Third, future studies could explore contextual factors that influence digital leadership in different educational settings. Cultural, institutional, and technological factors may shape how digital leadership is implemented across different countries and educational systems. Comparative studies examining digital leadership practices in different national contexts would provide valuable insights into how leadership strategies can be adapted to diverse educational environments.

Finally, further research should investigate the impact of digital leadership on student learning outcomes and teacher professional development. Understanding how leadership practices influence instructional innovation and student achievement would provide important evidence to support the development of digital leadership training programs for educational administrators.

Conclusion

The conclusions of this study can be summarized as follows:

1. Digital leadership is a critical competency for educational administrators in the digital era, enabling effective management of technological transformation in educational institutions.

2. Digital leadership consists of five key dimensions: digital vision, digital communication, digital professionalism, digital learning culture, and digital literacy.

3. Digital leadership significantly influences educational management effectiveness by supporting technology integration, organizational innovation, and teacher professional development.

4. Digital learning culture acts as a mediating variable that enhances the impact of digital leadership on educational outcomes by promoting collaboration, innovation, and continuous learning.

The proposed conceptual framework provides a theoretical foundation for future empirical research and practical guidance for developing digital leadership in educational contexts.

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Tourist Behavior in Helicopter Charter Service Selection in Las Vegas, Nevada, USA

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Abstract

This study examined tourist behavior in helicopter charter service selection in Las Vegas, Nevada, USA, with three objectives: (1) to describe behavioral characteristics of helicopter charter tourists; (2) to compare behavioral differences across demographic groups (gender, age, income level, and nationality); and (3) to propose evidence-based service development guidelines. An Explanatory Sequential Mixed Methods design was employed, comprising a quantitative phase using a validated Likert-scale questionnaire (n = 400; IOC = 0.87; Cronbach's α = 0.91) and a qualitative phase involving semi-structured in-depth interviews (n = 30; Inter-rater Reliability = 0.84). Results indicated that the primary market segment consists of affluent male professionals aged 35–55, predominantly using helicopter services for aerial sightseeing at an average expenditure of USD 4,250 per trip. Statistically significant behavioral differences were found across all demographic variables ($p < 0.05$). Four key service development priorities emerged: enhancing safety standards, developing 4E experience packages, building luxury hotel partnerships, and investing in social proof-driven digital marketing. These findings contribute to the luxury experiential tourism literature and offer actionable implications for operators seeking to deliver differentiated, segment-specific helicopter tourism services.

Keywords: tourist behavior, helicopter charter, Las Vegas, experiential tourism, luxury tourism

Background and Statement of the Problem

The global tourism industry has increasingly shifted toward experience-oriented consumption, wherein travelers seek meaningful, memorable, and distinctive experiences

rather than conventional sightseeing activities. Pine and Gilmore (1999) conceptualized this transformation as the Experience Economy, emphasizing that consumers derive greater value from immersive experiences than from standardized services. Within tourism, experiences integrating entertainment, education, escapism, and aesthetic engagement tend to generate stronger emotional connections and lasting memories (Mehmetoglu & Engen, 2011; Tung & Ritchie, 2011). Consequently, tourism operators have increasingly developed innovative services enabling visitors to interact with destinations in unique and engaging ways.

Helicopter charter tourism exemplifies this experiential tourism trend. Unlike conventional sightseeing, helicopter tours provide tourists with exclusive aerial perspectives, granting access to vantage points unavailable through ground-based transportation. Such experiences generate perceptions of uniqueness and memorability, which are important determinants of tourist satisfaction and behavioral intention (Kim et al., 2012; Volo, 2009). Prior research indicates that tourists participating in aerial sightseeing value personalized services, safety standards, and scenic exclusivity, particularly in premium tourism segments (Smith & Nichols, 2015). Globally, the helicopter tourism market is projected to grow substantially in the coming decade (Market Research Future, 2025), underscoring the need for empirical investigation into the behavioral factors driving consumer demand.

Las Vegas, Nevada, represents one of the most prominent helicopter tourism destinations in the United States due to its proximity to iconic attractions such as the Grand Canyon, Hoover Dam, and the Las Vegas Strip. The city attracts millions of international visitors annually and generates strong demand for unique, high-value tourism experiences. The expansion of luxury tourism markets has further strengthened demand for helicopter charter services. Research on luxury consumption suggests that high-income travelers seek distinctive, status-enhancing experiences that differentiate them from mass tourism activities (Wiedmann et al., 2009; Williams & Baláž, 2015). This behavior aligns with Veblen's (1899) concept of conspicuous consumption, in which luxury goods and experiences serve as symbols of social status.

Tourist decision-making is also strongly influenced by digital information channels and online reviews. Travelers increasingly rely on social media, online travel

platforms, and user-generated content to evaluate tourism services (Xiang & Gretzel, 2010). For premium services involving high financial costs and perceived safety risks, online reputation management plays a critical role in shaping service selection behavior (Lepp & Gibson, 2003; Sparks & Browning, 2011).

Despite the rapid growth of helicopter tourism in destinations such as Las Vegas, empirical research specifically examining tourist behavior within this niche premium aviation tourism segment remains significantly limited. Existing tourism literature predominantly addresses general travel motivations or broad destination choice rather than segment-specific experiential services such as helicopter charter tourism. Furthermore, while prior studies have demonstrated that tourist motivations and behavioral patterns vary across demographic characteristics such as gender, age, income, and nationality (Crompton, 1979; Pearce & Lee, 2005; Reisinger & Turner, 2003), no study has systematically applied these demographic comparisons to the helicopter charter tourism context in Las Vegas. This study addresses this gap by providing empirical evidence on tourist behavior in helicopter charter service selection and comparing behavioral differences across demographic groups, with practical implications for improving service development strategies in the premium experiential tourism industry.

Research Objectives

1. To describe the behavioral characteristics of tourists who selected helicopter charter services in Las Vegas, Nevada, USA.
2. To compare tourist behavioral differences in helicopter charter service selection across demographic characteristics (gender, age, income level, and nationality).
3. To propose evidence-based service development guidelines for helicopter charter tourism operators in Las Vegas, Nevada, USA.

Significance of the Study

Academic Contributions. This study extends existing theoretical frameworks-Push-Pull Theory and the Experience Economy-to the underexplored context of helicopter charter tourism. It contributes empirical evidence on luxury experiential

tourism behavior and advances mixed-methods research designs applicable to niche experiential tourism markets.

Practical Implications. Helicopter charter operators in Las Vegas can apply the findings to design segment-specific services aligned with each demographic group's behavioral patterns, thereby strengthening market positioning and customer satisfaction.

Policy Contributions. Policymakers and destination management organizations can leverage the results to support sustainable growth of premium aerial tourism in Las Vegas and comparable international destinations.

Conceptual Framework and Hypotheses

This study integrates Push–Pull Theory (Crompton, 1979; Uysal & Jurowski, 1994) and the Experience Economy (Pine & Gilmore, 1999) framework to explain tourist behavior in helicopter charter tourism. The independent variables are demographic characteristics (gender, age, income level, and nationality). The dependent variables are tourist behavioral indicators, including purpose of service use, expenditure per trip, service usage frequency, trip duration, and information discovery channel. These behavioral outcomes subsequently inform service development strategies for helicopter tourism operators. Perceived risk (Lepp & Gibson, 2003) is recognized as a potential moderating variable influencing the relationship between demographic characteristics and behavioral outcomes, particularly regarding safety-related decision-making.

Based on the conceptual framework, the following hypotheses were tested:

H1: Gender differences significantly influence helicopter tourism behavior (expenditure and service purpose).

H2: Age differences significantly influence helicopter tourism behavior (purpose and usage pattern).

H3: Income level significantly influences helicopter tourism spending and service frequency.

H4: Nationality significantly influences tourism purpose, route preferences, and trip duration.

Research Methodology

This study employed an Explanatory Sequential Mixed Methods design (Creswell & Plano Clark, 2018), in which quantitative data were collected and analyzed first, followed by qualitative data to further explain and expand upon the quantitative findings. The two-phase design ensures methodological triangulation and enhances the credibility of findings.

Phase 1: Quantitative Study

A 63-item Likert-scale questionnaire (5-point scale) was administered to n = 400 tourists who had previously used helicopter charter services in Las Vegas. A multi-stage sampling procedure was employed as follows: (1) purposive selection of four major helicopter tourism operation zones in the Las Vegas metropolitan area as primary sampling units; (2) systematic random sampling of tourist departure points within each zone; and (3) convenience sampling of eligible tourists at each departure point. Sampling quotas by location were as follows: Las Vegas Strip (n = 150), Downtown Las Vegas (n = 100), Henderson (n = 80), and Boulder City (n = 70). Eligibility criteria required participants to have used a helicopter charter service at least once within the Las Vegas metropolitan area.

Content validity was established through expert panel review (five specialists in tourism management and research methodology), yielding an Index of Item-Objective Congruence (IOC) of 0.87. Reliability was confirmed via pilot study (n = 30), producing a Cronbach's alpha coefficient of 0.91, indicating high internal consistency (Nunnally, 1978).

Data were collected from January to June 2025 and analyzed using SPSS Version 29. Prior to inferential analysis, statistical assumptions were verified: normality was assessed using the Shapiro-Wilk test and histograms; homogeneity of variance was confirmed using Levene's test ($p > 0.05$ for all comparisons). Descriptive statistics (frequency, percentage, mean, and standard deviation) addressed Objective 1. To address Objective 2, Independent t-tests compared behavioral differences between two-group variables (gender and nationality), while one-way ANOVA (F-test) with Tukey HSD post-hoc tests compared behavioral differences across multi-group variables (income

level, age group, and nationality groups). Effect sizes were calculated using Cohen's d for t-tests and partial eta-squared (η^2) for ANOVA, following Cohen (1988). The statistical significance threshold was set at $p < 0.05$.

Phase 2: Qualitative Study

Semi-structured in-depth interviews were conducted with 30 purposively selected participants: 20 tourists (eligibility: prior helicopter charter service use in Las Vegas, willingness to elaborate on service experience) and 10 helicopter tour operators (eligibility: minimum two years operational experience, direct involvement in service design or customer management). Purposive sampling was employed to ensure information richness and diversity of perspectives.

Qualitative data were analyzed using Thematic Analysis (Braun & Clarke, 2006) supported by NVivo 14 software. Credibility was ensured through data triangulation (cross-referencing tourist and operator perspectives) and inter-rater reliability verification (coefficient = 0.84), indicating strong inter-coder agreement.

This study was conducted in accordance with ethical research principles. All participants provided informed consent prior to data collection. Anonymity and confidentiality of responses were strictly maintained throughout the research process.

Research Results

Objective 1: Behavioral Characteristics of Helicopter Charter Tourists

The majority of the sample were male (58.5%), aged 35–55 years (64.2%), held bachelor's degrees or higher (89.3%), reported household incomes above USD 100,000 per year (71.8%), and were predominantly American nationals (78.0%). Full demographic frequencies and percentages are presented in Table 1.

Table 1 Demographic Characteristics of Helicopter Charter Tourists (n = 400)

Characteristic	Category	Frequency	%
Gender	Male	234	58.5
	Female	166	41.5
Age	18–34 years	62	15.5
	35–55 years	257	64.2
	56 years and above	81	20.3
Education	Below bachelor's degree	43	10.7
	Bachelor's degree	198	49.5
	Above bachelor's degree	159	39.8
Household Income/yr (USD)	< $100,000	113	28.2
	$100,000–$150,000	143	35.8
	> $150,000	144	36.0
Occupation	Business / Finance	154	38.4
	Technical / Engineering	96	24.1
	Others	150	37.5
Nationality	American	312	78.0
	International	88	22.0

Note. Percentages are based on n = 400 respondents.

Regarding service usage behavior, the majority of tourists (61.0%) used helicopter charter services for the first time. The primary stated purpose was aerial sightseeing (53.5%), followed by special occasions such as anniversaries or birthdays (21.8%), business purposes (16.3%), and photography/video production (8.4%). Most trips lasted between 1.0 and 2.0 hours (57.8%), with an average expenditure of USD 4,250 per trip. Internet and social media were the most frequently cited information discovery channel (58.5%), indicating the strong influence of digital platforms on tourist decision-making. Table 2 presents the complete service usage behavior frequencies.

Table 2 Service Usage Behavior of Helicopter Charter Tourists (n = 400)

Behavior Variable	Category	Frequency	%
Usage Frequency	First time	244	61.0
	2–3 times	114	28.5
	More than 3 times	42	10.5
Purpose of Use	Aerial sightseeing	214	53.5
	Special occasions	87	21.8
	Business purposes	65	16.3
	Photography / video	34	8.4
Duration per Trip	Less than 1 hour	72	18.0
	1.0–2.0 hours	231	57.8
	More than 2 hours	97	24.2
Expenditure per Trip (USD)	< $2,000	48	12.0
	$2,000–$5,000	218	54.5
	> $5,000	134	33.5
Information Channel	Internet / Social Media	234	58.5
	Word of Mouth	99	24.8
	Travel Agency	67	16.7

Note. Frequencies and percentages are reported for categorical variables. Mean expenditure per trip = USD 4,250 (SD = 1,186); mean planned future usage = 2.14 trips/year (SD = 1.03).

Objective 2: Comparison of Tourist Behavior by Demographic Characteristics

Prior to inferential testing, normality and homogeneity of variance assumptions were verified and satisfied for all behavioral variables at the $p > 0.05$ level. Table 3 presents the results of Independent t-tests and one-way ANOVA comparisons.

Independent t-test results revealed statistically significant behavioral differences between gender groups in expenditure and service purpose ($t = 4.21$, $df = 398$, $p < 0.001$, Cohen's $d = 0.67$, medium-large effect). Male tourists reported higher average expenditure (M = USD 4,680, SD = 1,245) compared to female tourists (M = USD 3,820, SD = 1,102), and used the service for business purposes at a higher rate (21.4% vs. 9.6%), supporting H1. Significant differences were also found between American and international tourists in usage frequency and service purpose ($t = 3.87$, $df = 398$, $p < 0.001$, Cohen's $d = 0.55$, medium effect), supporting H4 (partial).

One-way ANOVA results indicated significant differences across income groups in expenditure and usage frequency ($F = 18.47$, $df = 2/397$, $p < 0.001$, $\eta^2 = 0.09$, medium effect), supporting H3. Post-hoc Tukey HSD tests confirmed that tourists with incomes above USD 150,000 spent significantly more per trip than those earning below USD 100,000 ($p < 0.001$). Significant differences across age groups in service purpose and usage pattern were also found ($F = 12.83$, $df = 3/396$, $p < 0.001$, $\eta^2 = 0.09$, medium effect), supporting H2. Tourists aged 35–55 most frequently used the service for special occasions, while those below 35 favored photography and social media-related experiences. Nationality group comparisons also revealed significant differences in route preference and trip duration ($F = 9.64$, $df = 3/396$, $p < 0.001$, $\eta^2 = 0.07$), further supporting H4.

Table 3 Comparison of Tourist Behavior by Demographic Characteristics (n = 400)

Variable	Groups Compared	Statistic	df	p-value	Effect Size	Result
Gender × Expenditure/Purpose	Male vs. Female	t = 4.21	398	< 0.001	d = 0.67	Significant*
Gender × Frequency/Duration	Male vs. Female	t = 2.94	398	< 0.01	d = 0.44	Significant*
Nationality × Frequency/Purpose	American vs. International	t = 3.87	398	< 0.001	d = 0.55	Significant*
Income × Expenditure/Frequency	3 income groups	F = 18.47	2/397	< 0.001	$\eta^2 = 0.09$	Significant*
Age × Purpose/Usage	4 age groups	F = 12.83	3/396	< 0.001	$\eta^2 = 0.09$	Significant*
Nationality × Route/Duration	4 nationality groups	F = 9.64	3/396	< 0.001	$\eta^2 = 0.07$	Significant*

Note. * Significance level $p < 0.05$. Effect sizes: Cohen's d for t-tests (small ≥ 0.20, medium ≥ 0.50, large ≥ 0.80); partial eta-squared (η^2) for ANOVA (small ≥ 0.01, medium ≥ 0.06, large ≥ 0.14; Cohen, 1988). Tukey HSD post-hoc tests were conducted for all ANOVA comparisons.

Objective 3: Service Development Guidelines

Thematic Analysis of 30 in-depth interviews identified four primary service development themes. These qualitative findings complement and elaborate upon the quantitative behavioral differences identified in Objective 2. Table 4 presents the themes and their prevalence among interview participants.

Table 4 Service Development Priorities from In-Depth Interviews (n = 30)

Priority	Key Content	% Suggested
Safety Standards Enhancement	Independent safety certification; detailed pre-flight briefing; transparent disclosure of pilot credentials. Addresses primary concern of male and high-income tourists.	93.3
4E Experience Package Development	Tailored packages by age and gender group; in-flight commentary; integration of Entertainment, Education, Escapism, and Aesthetics dimensions.	86.7
Strategic Partnership Building	Collaboration with luxury hotels and event companies to reach high-income and 35–55-year-old segments through trusted channels.	80.0
Digital Marketing and Social Proof	User-generated content campaigns; streamlined online booking system; review platform optimization. Targets younger and international tourists.	76.7

Note. Percentages indicate the proportion of interview participants who identified each priority as a primary recommendation.

Discussion

The finding that the majority of helicopter charter tourists held household incomes above USD 100,000 per year (71.8%) and education at bachelor's degree level or above (89.3%) is consistent with Volo (2009), who identified affluent, well-educated professionals as a primary market for experience-oriented tourism products. The Las Vegas helicopter tourism context extends this finding to aerial tourism specifically, where exclusive views of iconic destinations serve as status-enhancing experiences aligned with Veblen's (1899) theory of conspicuous consumption and Wiedmann et al.'s (2009) luxury value segmentation framework. Notably, unlike general luxury tourism markets, where conspicuous consumption is largely socially visible, aerial sightseeing experiences offer a form of "private luxury"—consumed in small groups and valued for personal memorability rather than public display—suggesting that prestige value in this segment may operate differently from conventional luxury goods contexts.

The gender-based expenditure difference ($t = 4.21$, $p < 0.001$, $d = 0.67$) supports Thrane's (2016) observation that male tourists tend to allocate higher expenditures to luxury tourism products. However, this finding warrants critical contextualization: the higher expenditure among male tourists in this study may partially reflect the greater proportion of business-purpose trips among male respondents (21.4% vs. 9.6% for females), where corporate budgets rather than personal discretionary income drive

spending. This nuance was not addressed in prior helicopter tourism research (Smith & Nichols, 2015) and represents an important distinction for operators designing gender-targeted marketing strategies.

Significant differences across income groups ($F = 18.47$, $\eta^2 = 0.09$) support Williams and Baláž's (2015) concept of price inelasticity among high-income consumers in premium tourism services. The medium effect size ($\eta^2 = 0.09$) suggests that while income explains meaningful variance in expenditure behavior, other factors—potentially including perceived service quality, route attractiveness, and social occasion—also contribute significantly. Future research incorporating psychographic variables could shed light on these additional determinants.

The age-group behavioral differences ($F = 12.83$, $\eta^2 = 0.09$) align with the Travel Career Pattern framework (Pearce & Lee, 2005), confirming that tourist motivations evolve across life stages. The finding that younger tourists (under 35) predominantly used helicopter services for photography and social media content creation represents a significant departure from prior helicopter tourism research, which has not explicitly documented this purpose-driven behavior. This suggests that social media platforms are not merely information channels but are actively shaping the tourism purposes and experience expectations of younger market segments—an insight with direct implications for product and marketing design.

The emphasis on safety standards as the highest-priority service development theme (93.3% of interview participants) aligns with Lepp and Gibson's (2003) risk perception framework and reflects the heightened safety sensitivity associated with aviation-based tourism. The 4E Experience Economy framework (Pine & Gilmore, 1999; Mehmetoglu & Engen, 2011) provides theoretical grounding for the qualitative finding on experience package development, confirming that experiential design should address all four dimensions to maximize tourist memorability. The strategic partnership priority supports Kotler and Keller's (2016) Value Delivery Network concept, while the strong emphasis on digital marketing and social proof reflects Xiang and Gretzel's (2010) and Sparks and Browning's (2011) findings on digital information's role in tourism decision-making.

Overall, these findings highlight that helicopter charter tourism in Las Vegas operates within the broader luxury experiential tourism market, where consumer

behavior is shaped by demographic characteristics, perceived prestige, experiential value, and digital information channels.

Theoretical Contributions

This study contributes to the academic literature on experiential and luxury tourism behavior by extending Push–Pull Theory (Crompton, 1979; Uysal & Jurowski, 1994) and the Experience Economy framework (Pine & Gilmore, 1999) to the underexplored context of helicopter charter tourism. The findings support the Travel Career Pattern theory (Pearce & Lee, 2005) by confirming that tourist motivations and usage patterns vary significantly across age groups and life stages. By combining quantitative behavioral analysis with qualitative operator insights, this study advances mixed-methods methodological approaches to studying niche experiential tourism markets. Importantly, the identification of photography and social media content creation as a primary use purpose among younger tourists extends existing theoretical understanding of how digital culture reshapes experiential tourism motivations.

Practical Contributions

For helicopter tour operators, this study highlights the importance of market segmentation strategies targeting affluent middle-aged professionals as the core customer base, while developing specialized offerings for younger, photography-oriented tourists and international visitors. Safety assurance through transparent pilot credential communication and pre-flight briefing is identified as a critical trust-building strategy. The 4E experience package design framework offers operators a structured approach to creating memorable, review-worthy experiences. Strategic collaborations with luxury hotels and digital marketing investments in user-generated content are recommended as cost-effective channels for reaching high-value tourist segments.

Limitations and Future Research Directions

This study has several limitations. First, the sample was restricted to tourists who had already used helicopter charter services in Las Vegas, which may limit generalizability to other aviation tourism destinations or non-users. Second, self-reported

questionnaire data are subject to recall and social desirability biases; future studies could supplement these with objective booking data or behavioral observation. Third, the study examined demographic variables as primary predictors of behavior; psychographic characteristics, perceived risk, travel motivation, and destination image—which may explain additional variance—were not incorporated. Future research should integrate these variables for a more comprehensive behavioral model.

Additionally, future comparative or cross-cultural studies examining helicopter tourism in other destinations (Hawaii, Grand Canyon region, Dubai, New Zealand) could provide deeper insights into how cultural, geographic, and market factors influence behavior in luxury experiential tourism. Longitudinal designs could track how behavioral patterns evolve alongside digital tourism technologies and shifting market demographics.

Recommendations

Managerial Recommendations

1. Design differentiated, segment-specific service packages: target high-income male groups with safety-emphasized Corporate Tours; engage younger tourists with social media-worthy, photography-optimized experiences; serve international visitors with multilingual communication and cultural interpretation services.

2. Invest in transparent safety communication, including display of pilot credentials, independent safety certification, and detailed pre-flight briefing procedures to build customer trust among safety-sensitive demographic segments.

3. Develop 4E experience packages encompassing Entertainment, Education, Escapism, and Aesthetics dimensions, primarily tailored to the 35–55 age group with customizable options for other segments.

4. Build strategic partnerships with luxury hotels and event planning companies to establish distribution channels aligned with the preferences of high-income and middle-aged tourist segments.

5. Invest in digital marketing emphasizing social proof and user-generated content, supported by a user-friendly online booking system, to effectively reach younger tourists and international visitors.

Policy Recommendations

1. Destination management organizations should incorporate helicopter charter tourism into broader luxury tourism development strategies for Las Vegas, leveraging the sector's strong appeal to high-spending visitor segments.

2. Aviation tourism regulators should consider establishing standardized independent safety certification frameworks that operators can use to transparently communicate safety credentials to tourism consumers.

Future Research Directions

1. Future studies should incorporate psychographic variables (travel motivation, risk perception, lifestyle, destination image) to develop more comprehensive behavioral models for premium experiential tourism.

2. Comparative research across helicopter tourism destinations (e.g., Hawaii, Dubai, New Zealand) and longitudinal designs tracking behavioral change over time would strengthen theoretical contributions to the luxury aerial tourism literature.

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Community-Based Care for Homeless Individuals with Schizophrenia: Improving Mental Health and Urban Safety

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Abstract

Urbanization and social inequality have exacerbated to the growth of vulnerable populations who face difficulties accessing continuous mental health care. Among these groups, homeless individuals with schizophrenia represent a particularly high-risk population due to the chronic nature of the disorder and the instability of their living conditions. Untreated schizophrenia may lead to severe psychiatric symptoms, social isolation, and socio-environmental risks affecting both the individuals and surrounding communities.

This academic article explores community-based care approaches for homeless individuals with schizophrenia in urban environments. The article synthesizes existing knowledge on schizophrenia, homelessness, community mental health services, and behavioral incentive mechanisms to propose a conceptual framework for improving mental health stability and enhancing community safety.

The discussion emphasizes the imperative of integrating community networks, family support systems, and primary healthcare services to create sustainable care mechanisms for vulnerable populations. Community health volunteers, local leaders, and healthcare providers play critical roles in monitoring patient conditions, facilitating treatment continuity, and strengthening community resilience.

The article concludes that community-based mental health care, combined with collaborative governance and behavioral support mechanisms, can contribute to more effective management of schizophrenia among homeless populations while promoting secure and pluralistic urban communities.

Keywords: Community-Based Care, Schizophrenia, Homeless Population, Community Safety

Introduction

Mental health disorders are increasingly recognized as a significant global public health concern. Among these conditions, schizophrenia is a severe and chronic psychiatric disorder that affects cognition, perception, emotional regulation, and social functioning (World Health Organization, 2023). Individuals living with schizophrenia often experience difficulties maintaining employment, relationships, and stable living conditions, which may increase their risk of homelessness.

Homelessness itself is a complex social phenomenon inextricably linked to poverty, unemployment, lack of social support, and limited access to healthcare services. Previous studies indicate that individuals experiencing homelessness have significantly higher rates of mental illness compared with the general population (Fazel et al., 2014). In particular, schizophrenia is disproportionately prevalent among homeless populations, where unstable living environments make it difficult to maintain regular treatment and medication adherence.

In urban environments, untreated mental illness among homeless individuals can create multiple social challenges. These challenges include increased health risks for individuals, strain on healthcare systems, and heightened concerns about public safety within communities (United Nations, 2020). Urban communities with dense populations often face greater difficulties managing mental health crises due to limited coordination between healthcare services, social support systems, and local governance mechanisms.

Community-based mental health care has emerged as an important approach to addressing these challenges. Rather than relying solely on institutional treatment, community-based approaches emphasize the integration of healthcare services, community networks, and social support systems. This approach allows individuals with mental illness to receive continuous support within their living environments while promoting social inclusion and reducing stigma (World Health Organization, 2021).

The Khlong Toei community in Bangkok represents one of the largest and most densely populated urban communities in Thailand. The community has long faced challenges related to poverty, informal housing, and vulnerable populations, including homeless individuals experiencing mental illness. Addressing mental health issues in

such contexts requires collaborative efforts between healthcare providers, community leaders, families, and social welfare agencies.

This article explores conceptual approaches to community-based care for homeless individuals with schizophrenia and examines how integrated support systems can improve mental health outcomes and enhance community safety in urban environments. Addressing a gap in existing research, the study proposes an integrated community-based care framework that combines healthcare services, community participation, and behavioral support mechanisms to strengthen mental health stability and urban resilience.

Schizophrenia and Mental Health Vulnerability

Schizophrenia is a chronic psychiatric disorder characterized by disturbances in thought processes, perception, emotional responsiveness, and social behavior. Symptoms often include hallucinations, delusions, disorganized thinking, and impaired cognitive functioning. Without appropriate treatment and monitoring, individuals with schizophrenia may experience recurrent episodes that significantly affect their quality of life (World Health Organization, 2023).

Early diagnosis and continuous treatment are therefore essential for effective disease management. However, individuals living in unstable conditions, such as homelessness, often face substantial barriers to accessing mental health services. These barriers include financial constraints, social stigma, and limited availability of community-based mental health services (Fazel et al., 2014).

Homelessness and Urban Mental Health Challenges

Homeless populations experience multiple layers of vulnerability, including health problems, unemployment, and social exclusion. Mental illness is both a contributing factor to and a consequence of homelessness. Research indicates that homeless individuals are significantly more likely to suffer from severe mental disorders compared with the general population (Fazel et al., 2014).

In urban settings, the presence of untreated mental illness among homeless populations may lead to complex social challenges. Community members may experience concerns related to safety, public health, and social stability. Consequently, addressing

mental health issues among homeless populations is not only a healthcare priority but also a crucial aspect of sustainable urban development (United Nations, 2020).

Community-Based Mental Health Care

Community-based mental health care emphasizes service delivery within the local community rather than relying solely on institutional care. This approach promotes collaboration between healthcare professionals, families, community organizations, and local governance structures. According to the World Health Organization (2021), community-based mental health services can improve treatment accessibility, reduce relapse rates, and promote social reintegration for individuals with severe mental illness.

Community participation is therefore a key factor in supporting vulnerable populations. Community health volunteers and local leaders often play essential roles in monitoring patient conditions, providing emotional support, and facilitating access to healthcare services.

Behavioral Incentive and Social Support Mechanisms

Behavioral incentive strategies have been widely applied in health promotion and behavioral change interventions. These strategies are based on the principle that individuals are more likely to adopt positive behaviors when appropriate incentives or supportive environments are present (Thaler & Sunstein, 2008).

In the context of schizophrenia care, behavioral incentives may include structured support systems, medication reminders, social encouragement, and community monitoring. Such mechanisms can help increase treatment adherence and reduce relapse among patients living in unstable social conditions.

Toward Safer and More Inclusive Urban Communities

The integration of community-based mental health care with urban governance mechanisms can contribute significantly to safer and more inclusive cities. Collaborative governance frameworks involving healthcare institutions, local governments, community organizations, and civil society can strengthen urban resilience and promote sustainable development (Ansell & Gash, 2008).

When communities actively participate in mental health support systems, they become better equipped to respond to crises, support vulnerable populations, and foster social cohesion. These approaches align with global development frameworks that emphasize inclusive cities and healthy communities (United Nations, 2020).

Conceptual Framework of the Community-Based Care Model

Figure 1 illustrates the conceptual framework of the proposed community-based care model for homeless individuals with schizophrenia. The framework emphasizes the integration of healthcare services, community participation, and behavioral support mechanisms in order to promote treatment continuity and improve mental health stability. The model also highlights the role of community networks and collaborative governance in strengthening safety and resilience within urban communities.

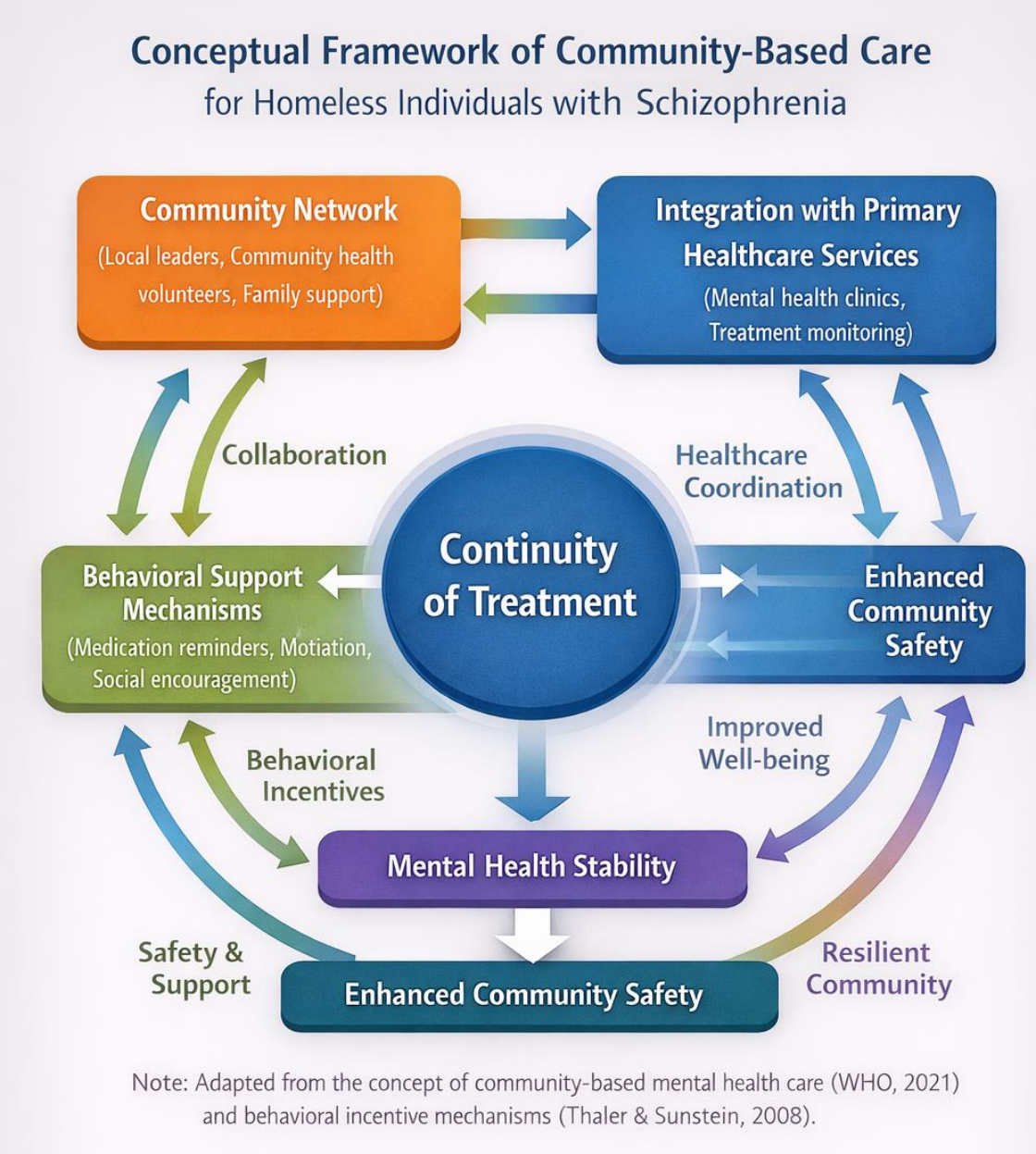


Figure 1: Adapted from the concept of community-based mental health care (WHO, 2021) and behavioral incentive mechanisms (Thaler & Sunstein, 2008).

The conceptual framework illustrates the dynamic relationships among three core components: community participation, behavioral incentive mechanisms, and primary healthcare integration, which collectively contribute to mental health stability and community safety. Community participation, including the involvement of local leaders, families, and community health volunteers, functions as a foundational support system that enables continuous monitoring and social support for individuals with schizophrenia.

Behavioral incentive mechanisms act as reinforcing factors that promote treatment adherence and positive health behaviors through structured support, reminders, and motivational strategies. These mechanisms strengthen the effectiveness of community participation by encouraging consistent engagement with care processes.

Primary healthcare integration serves as a coordinating mechanism that connects community-based support with formal mental health services, ensuring continuity of care and early intervention in cases of symptom relapse. The interaction among these components creates a synergistic effect that enhances both individual mental health outcomes and broader community safety.

The development of this framework is grounded in community-based mental health care principles (World Health Organization, 2021), which emphasize person-centered and rights-based approaches, and behavioral incentive theory (Thaler & Sunstein, 2008), which explains how supportive environments can influence health-related behaviors. In addition, the model incorporates collaborative governance concepts (Ansell & Gash, 2008) to highlight the role of multi-stakeholder coordination in addressing complex urban health challenges.

Table 1 presents the key elements of the proposed community-based care model. The model integrates three primary components: community participation, behavioral incentive mechanisms, and healthcare service coordination.

Table 1 Elements of Community-Based Care Model for Homeless Individuals with Schizophrenia

Component	Description	Expected Outcomes
Community Participation	Involvement of community leaders, families, and community health volunteers in monitoring and supporting patients	Improved patient follow-up and social support
Behavioral Incentive Mechanisms	Use of motivation, reminders, and supportive environments to encourage treatment adherence	Increased medication compliance and reduced relapse
Primary Healthcare Integration	Collaboration between community networks and mental health service providers	Improved access to treatment and continuity of care
Community Monitoring System	Community-based tracking and support mechanisms for patients with severe mental illness	Early detection of symptom relapse
Collaborative Governance	Coordination among healthcare institutions, local government, and community organizations	Strengthened community safety and social resilience

Table 1 summarizes the key components of the proposed community-based care model. The integration of community participation, behavioral support mechanisms, and healthcare service coordination is instrumental in improving treatment continuity and enhancing mental health stability among homeless individuals with schizophrenia. Furthermore, collaborative governance among local stakeholders facilitates the reinforcement of community safety and resilience.

Conclusion

Mental health challenges among homeless individuals with schizophrenia constitute a multifaceted challenge that intersects public health, social welfare, and urban governance. Traditional institutional approaches alone fall short of addressing the complex nature of this problem. Community-based care approaches provide a robust framework for improving treatment continuity, enhancing mental health stability, and strengthening community safety. By integrating healthcare services, community networks,

and social support systems, urban communities can develop more inclusive mechanisms for supporting vulnerable populations.

Future initiatives should focus on prioritize fortifying collaboration between healthcare providers, community leaders, and policy institutions to create sustainable mental health support systems in urban environments. Such efforts will not only improve the quality of life of individuals with schizophrenia but also contribute to the development of safer and more resilient communities.

Contributions and Implications

This study advances existing knowledge by proposing an integrated conceptual framework that combines community-based mental health care, behavioral support mechanisms, and collaborative governance to address the complex needs of homeless individuals with schizophrenia in urban environments. Unlike prior studies that focus primarily on clinical or institutional approaches, this study emphasizes the integration of community participation and social support systems to ensure treatment continuity and enhance mental health stability.

Academically, the study contributes to the literature by offering a multidimensional framework that links healthcare services, community networks, and behavioral strategies within an urban context. Practically, the proposed framework provides guidance for healthcare providers, community leaders, and social workers in developing more effective and sustainable care systems for vulnerable populations. From a policy perspective, the findings highlight the importance of integrated urban health policies that foster collaboration among healthcare institutions, local governments, and community organizations to improve both mental health outcomes and community safety.

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Recent Trends of Higher Education in India and Future Prospects

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Abstract

This study explores recent trends in higher education in India and examines future prospects within the framework of the National Education Policy 2020 (NEP-2020). Adopting a conceptual and policy analysis approach, the study synthesizes data from policy documents, government reports, and relevant literature to analyze key transformations in the sector. Higher education plays a critical role in shaping a knowledge-based society and driving national development; however, the Indian education system continues to face challenges related to access, equity, and quality. The paper adopts a conceptual and policy-based analysis to highlight key transformations, including the shift toward multidisciplinary learning, skill-based education, flexible curricula, and student-centered approaches. Emphasis is placed on the integration of Information and Communication Technology (ICT) as a crucial enabler for expanding access, enhancing teaching–learning processes, and improving institutional efficiency.

The findings indicate that NEP-2020 provides a comprehensive roadmap to reform higher education by promoting research, innovation, and global competitiveness. Initiatives such as digital learning platforms, open and distance education, and the establishment of regulatory bodies aim to strengthen governance and quality assurance. However, the effective implementation of these reforms remains contingent upon addressing critical barriers, including digital literacy gaps, teacher competency, infrastructure disparities, and socio-economic inequalities.

Furthermore, the study highlights the importance of continuous professional development for educators and the need for institutional readiness in adopting technological and pedagogical innovations. The future of higher education in India depends on the successful alignment of policy, practice, and stakeholder engagement. It is concluded that while NEP-2020 presents significant opportunities, its impact will largely depend on strategic implementation, adaptability, and sustained investment in the education sector to achieve inclusive and sustainable growth.

Keywords: Higher Education, NEP-2020, ICT Integration, Educational Reform

Introduction

Education is a fundamental driver of national development, particularly in a diverse and complex society such as India. India is characterized by significant socio-economic diversity and complexity. These conditions create multiple challenges that influence national development. The higher education system plays a crucial role in shaping human capital, fostering innovation, and supporting societal transformation. The concepts and future vision of Indian Universities according to NEP-200 as "Recent Trends in Education for Future Prospects" all the possible but highly critical factors were discussed. The inter and intra competition among the Global and Bharat Universities with respect to Research, Training and Extension activities representation create healthy environment for their position and some critical issues, which have to be raised in a national policy for the development of educational policies and its implementations for the Higher people of India reflect through National Education Policy-2020 now implementing stage. The National Education Policy 2020 (NEP-2020) emphasizes quality, skill-based, and student-centered education across all levels. Digital literacy and practices according to the need and acceptability is the basic problem in cross-country education system.

The policy lays the groundwork for a corrective course of action that offers all citizens, right from their impressionable young years, the resources to learn, think and grow critically and creatively. It conceives for India, an education system that is on global par, and regardless of social and economic backgrounds, access to high-quality education to all. While this is an ambitious goal, one that requires restructuring of the entire education environment and its governance, the following provisions have made headway in terms of the direction of thinking. The New Education Policy was released under the Government of India's Ministry of Human Resource Development (MHRD) on 30 July 2020. With the motto of Educate Encourage Enlighten, this is the first education policy to be released in the last 34 years in India. The aim of the policy is to prepare the children of India with 21st century skills. The policy is founded on the three pillars of Research,

Innovation, and Quality, with the objective of developing India into a knowledge super power.

Educational problems and its present scenario in India are highlighted through its policy from elementary level to higher education apart from this the basic problem of education related with downtrodden are also exported through critical argument. According to geographical condition of India and densely populated Higher people and their educational status, living conditions, constitutional amendments, special provisions and exemplarily form of first-hand research data are explored in this book. Research related to Higher education in India and their findings, which will be help for making policy for the specific community of India, are also given in one of chapter of this book. The book is comprehended with thirteen chapters so called as chapters associated and integrated with thirteen chapters so called as parts of the books based on future of Indian Universities and National education Policy- 2020 remarkable features. Though, Madhya Pradesh is at Central India and it is the first state who has implemented NEP-2020 compare to other state of India. Therefore, the geographical conditions, populations and demographics variations are considered for establishment of New Universities according to NEP-2020. Digital literacy, competent teachers and implementations can change, reshape our University Education with International Universities collaboration targeted fifty percent of higher education literacy up to 2050 as National Agenda in order to success NEP-2020.

With regards to Higher Education, NEP 2020 mandates that GER be 50% by 2035, with an additional 35 million (3.5 crore) seats added. The policy envisions broad-based, multi-disciplinary, holistic education with flexible curricula, creative combination of subjects, integration of vocational education, utilization of technology, and development of multiple entries and exit points. In fact, universities such as the IITs and IIMs will be utilized as benchmark models. A complete restructuring of undergraduate and postgraduate programs will ensure that certifications be awarded each year, and credits are transferable. Yes, flexibility is embedded into the very ethos of the new policy. To set the tone, the Higher Education Commission of India (HECI) will act as an umbrella organization for higher education, whilst National Research Foundation (NSF) will take on the role of an apex body to foster a research-oriented mind-set and build research capacities across

the landscape. It is important to note that private and public institutions will be governed by the same set of principles for academic standards, accreditation and regulation. Ultimately, the policy envisages that every college develops into an autonomous degree-granting college or constituent college of a university. Some noteworthy provisions to pay heed to include – financial aid to students, expansion of open and distant learning, faculty training and motivation, and promotion of Indian languages.

NEP-2020 stresses the need to set up a Gender Inclusion Fund, so as to build the nation's capacity of providing equitable quality education to all students, be it a girl or transgender student. Add to this, Special Education Zones for socio-economically disadvantaged groups, and you've got concerted efforts by the government to change the landscape of rural, remote areas. Given the need of the hour, an autonomous body hailed as the National Educational Technology Forum (NETF) will be set up for the free exchange of ideas on the investment and use of technology. The aim is to enhance and alleviate learning, assessment, planning and administration. In summation, the centre and state cabinets will work together to increase public investment in the education sector, thus reach 6% of Gross Domestic Product at the earliest. Having gone through the highlights of NEP 2020, what do you foresee for the future? Is this policy a boon or a bane? Is it the right step forward? Will it come to fruition as planned? We believe that the measure of its success will much depend upon its implementation, acceptance and interpretation by institutions. That being said, the nation must fully commit itself to see the aforementioned reforms through.

During the last fifty years, several milestones have been crossed educational changes both theoretical and practical prospects. Beginning with a situation where four out of five persons were illiterate, and only two out of ten children went to school; it has not been an easy task to meet the constitutional commitment. The country began its journey towards the goal of universal elementary education for all by opening more and more primary schools across the country. The system has grown huge in size and coverage. The Indian Constitution, adopted in 1950, directed the State to ensure provision of basic education for all children up to the age of fourteen years within a period of ten years. The struggle to achieve this basic commitment began immediately. Today nearly four out of five children in the age group 6 14 years are in the school. Two

out of three persons are functionally literate. Progress achieved is by no means small. But it falls short of meeting the goal of Education for All (EFA).

In the pursuit of the goal of providing basic education for all, the National Policy on Education (NPE) and the follow up actions on the recommendations of the policy in 1986 has been a major landmark. The World Declaration on EFA adopted soon after in 1990 gave further boost to the various processes already set in motion in the country. As the analysis presented in the document demonstrates, the last decade of the century has witnessed tremendous progress in the area of basic education in the country. Yet, it is realized that the journey is not yet over. The main task is not to lose the momentum created by the progress made in the last decade. It is necessary to consolidate the gains and capitalize on the enlarged base created by the progress. It is realized that the methods here to adopt may not be appropriate for crossing the difficult hurdles in the last leg of the journey towards EFA. The strategy has to be such that the goal is achieved within the first few years of the next century. The future policies and programmes are to be guided by this perspective. The following paragraphs set forth the directions in which the EFA effort was focused in the years to come beyond 2000.

Objectives of the Study

This article aims to:

- To analyze recent trends in higher education in India within the context of ongoing educational reforms.

- To examine the key features and policy directions of the National Education Policy 2020 (NEP-2020).

- To discuss the role of Information and Communication Technology (ICT) in enhancing access, quality, and efficiency in higher education.

- To identify major challenges and constraints in the implementation of higher education reforms in India.

- To highlight future prospects and strategic directions for the development of higher education under NEP-2020.

Significance of the Study

This article contributes to the understanding of higher education reform in India by providing a comprehensive analysis of recent trends within the framework of the National Education Policy 2020 (NEP-2020). It offers a conceptual synthesis of key policy directions, particularly in relation to multidisciplinary education, student-centered learning, and the integration of Information and Communication Technology (ICT).

From an academic perspective, the study enriches the existing literature by connecting policy discourse with emerging educational practices in a developing country context. It highlights how structural reforms and technological integration can influence access, quality, and institutional efficiency in higher education systems.

From a practical perspective, the article provides insights for policymakers, educators, and institutional leaders in designing and implementing effective educational strategies aligned with NEP-2020. It also identifies critical challenges—such as digital literacy gaps, infrastructure limitations, and teacher readiness—that must be addressed to ensure successful reform implementation.

Ultimately, this study supports future policy development and strategic planning by outlining both opportunities and constraints, thereby contributing to more inclusive and sustainable higher education development in India.

Provision of Elementary Education for All – Continuing the Unfinished Task

Approaches to achieve the goal of universal elementary education in the years to come have to measure up to the magnitude and complexity of the task, which has so far remained incomplete. Efforts to pursue this goal were guided by three broad concerns:

- The national resolve, as stipulated in the National Policy on Education, to provide free and compulsory education of satisfactory quality to all children up to the age of fourteen years.

- The political commitment to make the right to elementary education a Fundamental Right and enforcing it through necessary statutory measures.

Enactment of 73rd and 74th Constitutional amendments which have set, the stage for greater decentralization and a significantly enhanced role for local bodies, community organizations as well as voluntary agencies in the efforts towards UEE.

Further, recognizing the importance of the primary education sector, the Central Government has been working with the State Governments on a principle of shared responsibility for achieving the goals of UEE. This becomes even more important in the context of the commitment to make 'right to elementary education' a fundamental one. With the magnitude of the unfinished task, the Government of India will continue supporting the initiatives in primary education while promoting the capacities of the State Governments to meet the challenges effectively. Mobilizing additional resources to reach the critical mark of six per cent of the GDP for education is a goal towards which the country will continue to strive.

It is the responsibility of Government to provide quality education from elementary to higher level to their people by which development of Nation is possible. Education is the key by which social development is possible irrespective of any factors acts as barriers directly or indirectly for the development. In teaching learning process, the core principle according to the objective to see the maximum output in the part of learner. The principle of instructional technology and learning technology are associated with the learners' achievement. Intervention of technology in the teaching learning process as a result of Educational Technology is the product of instructional and learning process. Use of Information Communication Technology (ICT) is the burning issues now a day in our teaching learning process. For many of us, the lure of computers is a powerful one. However, many of us also refrain from using computers for fear of failure. We want to hone computer skills, but are scared to make the effort because we lack those very skills. Too many of us, especially in the field of learning, are caught in this modern tug of war. Better understanding in the part of learners, applications of pedagogical issues related to learning process with respect to their developmental stages are the remarkable area for educational problems.

The basic objective of Instructional Technology material is not so much to replace the teacher as to change the teacher's role entirely. As such, Instructional Technology must be extremely well designed and sophisticated enough to mimic the best teacher, by combining in its design the various elements of the cognitive processes and the best quality of the technology. With today's Instructional Technology courseware, once a programme has been designed and built in with the appropriate responses, it

should be flexible and permit change and alteration. We shall look at the usage, advantages and disadvantages of Instructional Technology in education and training. Instructional Technology is a term frequently heard and discussed among educational technologists today. Unless clearly defined, the term can alternately mean a judicious mix of various mass media such as print, audio and video or it may mean the development of computer-based hardware and software packages produced on a mass scale and yet allow individualized use and learning. In essence, Instructional Technology merges multiple levels of learning into an educational tool that allows for diversity in curricula presentation. Instructional Technology is the exciting combination of computer hardware and software that allows you to integrate video, animation, audio, graphics, and test resources to develop effective presentations on an affordable desktop computer. (Fenrich, 1997).

Learning Technology

The basic objective and responsibility of any Government all over the world is to provide and avail quality education for all from elementary level to higher education. In our teaching learning process the core principle according to the national goal how to see the maximum output in the part of the learners. The principle of Instructional Technology (IT) and Learning Technology (LT) are associated with the Teachers, Teaching Environments and Learners' achievement. Intervention of technology in the teaching learning process as a result of Educational Technology is the product of instructional and learning process. For many of us, the lure of computers is a powerful one. However, many of us also refrain from using computers for fear of failure. We want to hone computer skills, but are scared to make the effort because we lack those very skills. Too many of us, especially in the field of learning, are caught in this modern tug of war. ICT in teaching learning process in both LT and IT trying to facilitates pedagogical issues with respect to other learning constraints of both learners and teachers. The emerging concept of media approach of teaching learning changed with the integration different media with single platform as Multi Media (MM) approaches of teaching learning. All the interventions of hardware and software approach of teaching learning environment lead by different theories behind the learning principles.

Gagne's theory, Constructivist theory, and Constructionism theory

Gagne's theory, Constructivist theory, and Constructionism theory are all psychological theories, aiming to help learners to achieve learning objectives with effectiveness and efficiency (Gagne, 1970; Piaget, 1964, 1974), as well as to help learners understand in a faster, and stable way (Pimpan Techakup, 2001) which complies with the National Education Act (B.E. 2542), Section 24, which reads: "In organizing the learning process, educational institutions and agencies concerned shall provide training in thinking process, management, how to face various situations and application of knowledge for obviating and solving problems." This is to make Thai learners capable to develop themselves and compete with the world's knowledge based economy. Moreover, Section 66 also reads "learners shall have the right to develop their capabilities for utilization of technologies for education as soon as feasible so that they shall have sufficient knowledge and skills in using these technologies for acquiring knowledge themselves on a continual lifelong basis." This is to make Thai learners capable to use technology for seeking knowledge.

Therefore, for the formation a good society as well as a good nation a teacher must possess confidence in his mind, satisfaction should possess in his job and value should be inculcated by them for a well-established society. Though, education is the nuclear part of our present technological based society but society without technical knowledge, power of reasoning, scientific inquiry mind is the society without soul. The solution of competitiveness between the individual and their holistic approach for solving day to day life problems required scientific, reason based approach in each and every span of life. The modern world is moving world different concepts and changes are appearing in our day to day life. As for our traditional way of thinking is concerned, it is past oriented and at some extent it deals present burning problems, but there is a lack of future awareness in our society, especially in our school going students. If there is lack of futuristic aspect in any concept it can't be serving properly to the mankind. In the present global race among the developed and developing countries all over world the present demand and future prospect for shaping the society is a great challenge and problem to each and every country. Todays' problem is the future requirement for survival of society. Within the ethos and culture of the social framework of any society

for its sustainability depends upon its educational system. Education system from elementary level to higher education and its implementing agencies are totally depending upon the teacher and its interventions in the system of teaching learning process. From primitive age to modern technology based society teacher lead the society through its instrument of both ethical and pragmatic value of educational system. Society bestowed upon four pillar through its educational system, implementing agencies, value system and teacher itself. Without teacher and teaching learning process it is not possible to create a complete society.

REDEFINEING EDUCATION BY USING COMPUTERS

In the world of globalization concept and it's acceptability in the knowledge society which shape the progress and development of any county are trying to redefine according to their needs. The Learning Community is an organization developed for the improvement in the ways of teaching and learning by the application of creativity and innovative practices in Education System. Objectives of the organization are to develop and promote Learning & Education and to provide a forum for discussion and deliberations on issues and problems related to Education in general and Learning in particular. Teachers are key players in maintaining and improving the quality of education and training systems. In the present era of technology, teacher's obligation is confined not only to acquire new knowledge and skills but to develop them continuously also. The education and professional development of every teacher needs to be seen as a lifelong task, and be structured and resourced accordingly. Professional development refers to activities to enhance professional career growth of teachers to foster teacher's growth. Professional development of teachers is to develop new insights into pedagogy and their own practices, and explore new or advanced understandings of contents and resources. To equip the teaching body with the skills and competences requires continuous professional development programmes. Need of out sources and localization of education through Information Communication Technology (ICT) in order to achieve National Goal through planning is a challenging issue for teachers, teacher educators, academicians, and scholars need single platform to deliberate and attain valuable and viable suggestions for professional development of teachers.

ICT in Education

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Present Need and Future Demands

It is the responsibility of the government makes people first of all educated and the quality of education need second wave for social development. Information Communication Technology (ICT) is the weapon in the field of education by which both the quality and quantity of educational objectives achievement. From primitive society to modern age technology based fourth wave of educational system depends on the teachers for promoting education according to the social need. World Wide Organizations for promoting education both quality and quantity are keeping a bird's-eye view for the

promotion of education in underdeveloped, developed and developing countries. Time to time the policy matter and decisions for global educational development through ICT application unknowingly reached to the unreached people needs.

ICT AND HIGHER EDUCATION

Higher education plays a pivotal role in the development of a country, as it is viewed as a powerful means to build knowledge-based society. In India, higher education imparted by universities is facing challenges in terms of Access, Equity and Quality. The Government of India has taken several initiatives during the Eleventh Five Year Plan period to increase access to higher education by adopting state specific strategies, enhancing the relevance of higher education through Curriculum reforms, Vocational programs, Networking, Information Technology adoption and Distance Education along with reforms in governance. It is considered that, the rapid spread of ICT applications has brought about markedly drastic technological, social and economic transformations. These changes have caused educational institutions, administrators, teachers to rethink their roles, teaching and vision for future. The sustainability of a nation in the era of knowledge economy depends on the effective educational system. Productivity is an economics concept where productivity is considered as the comparative analysis of input and outputs. In educational system the inputs are teachers, students, classroom material, equipment of teaching, methods of teaching and outputs are quantity and quality of student learning. The proper integration of ICT with teaching/learning environment increases education and increased productivity. ICT provides various opportunities to educational learners and make teachers aware of their new roles & responsibilities in teaching and learning process. The growing use of ICT will change many of the strategies employed by both Teachers and Students in the learning process. The role of ICT the educational administration is recurring and unavoidable. ICT has enabled us to monitor and evaluate what is learned, how it is learned and when and where learning took place. It is also enable the educational management system to discharge various functions such as, conduction of exams, coordination between potential institutes, alumni network. ICT also work for nontraditional students by providing internet based education to them anytime and anywhere and these internet technologies enables innovative ways of

teaching e.g. Tata Sky educational system., Zoom, Google meet ICT is going to play a vital role in bringing about qualitative change in every aspect of our life in general and that of governance of education.

Some Quick facts about Indian Higher Education

There are 14.6 million students undergoing Higher Education in India as of 2011. There has been a significant rise in enrolment from rural population in Higher Education. The GERs in rural areas have been rising steadily and expected to reach 12.84% by 2020. A growing number of women are expected to enroll in Higher Education Institutes. Currently over 6.1 million women are enrolled in Higher Education and is expected to grow to 12.15 million by 2020. There is a high demand from working professionals for Executive Education programs. Three Indian universities were listed in the Times Higher Education list of the world's top 200 universities Indian Institutes of Technology, Indian Institutes of Management, and Jawaharlal Nehru University in 2005 and 2006. Six Indian Institutes of Technology and the Birla Institute of Technology and Mathematics Pilani were listed among the top 20 Mathematics and Technology schools in Asia by Asia Week. The Indian School of Business situated in Hyderabad was ranked number 12 in global MBA rankings by the Financial Times of London in 2010 while the All India Institute of Medical Sciences has been recognized as a global leader in medical research and treatment. (Source: UGC Higher Education in India 2008 11th Five Year Plan Vol. II)

ICTs stand for Information and Communication Technologies (ICT) in the modern area of technology facilitating technology in teaching learning process. According to Blurton (1996); ICT is defined as "diverse set of technological tools and resources used to communicate, create, disseminate, store, and manage information". Technologies included in ICTs are: Radio and Television (broadcasting technology), Telephony, Computers, and the Internet. E Learning: Commonly associated with higher education, professional and corporate training, e learning encompasses learning at all levels, both formal and non formal, that uses an information network the Internet, an intranet (LAN) or extranet (WAN) whether wholly or in part, for course delivery, interaction and/or facilitation. Others also term it an online learning.

Open and distance learning: Open and distance learning is defined by the Common wealth of Learning as "a way of providing learning opportunities that is characterized by the separation of teacher and learner in time or place, or both time and place; learning that is certified in some way by an institution or agency; the use of a variety of media, including print and electronic; two way communications that allow learners and tutors to interact; the possibility of occasional face to face meetings; and a specialized division of labor in the production and delivery of courses. "The use of ICT has extended the scope of offering educational programmes at a distance. The off campus delivery was an option for students who were unable to attend the classes regularly. Today, many students are able to make this choice through technology facilitated learning settings. This make available the education everywhere, it is time and cost saving also. The major benefit of ICT implementation in education is it extending courses of choice to students of different backgrounds, cultures, perspectives. Learners are free to participate in learning activities at their convenience through online technologies. Eminent teachers from different parts of the country and abroad can be utilized for teaching at their convenience through mobile technologies and seamless communication technologies that support 24x7 teaching and learning for instance NPTEL (National Programme on Technology Enhanced Learning, India, 2007), EKLAVYA Technologies Channel, India, 2007, Tata Sky Active education classrooms etc. All these above technologies are the fruitful result of ICT implementation in education sector which provide a new direction in modern education. All these educations can be provided through Teleconferencing, Videoconferencing, Web based conferencing, Audio conferencing and other ICT technologies.

Teleconferencing: refers to "electronic communication among people located at two or more different places." There are four types of teleconferencing based on the nature and extent of interactivity and the sophistication of the technology: 1) audio conferencing; 2) audio graphic conferencing, 3) videoconferencing; and 4) Web based conferencing. Audio conferencing: involves the live (real time) exchange of voice messages over a telephone network. When low bandwidth text and still images such as graphs, diagrams or pictures can also be exchanged along with voice messages, then this type of conferencing is called audio graphic. Non-moving visuals are added using a computer keyboard or by drawing/writing on a graphics tablet or whiteboard. Video

conferencing allows the exchange not just of voice and graphics but also of moving images. Video conferencing technology does not use telephone lines but either a satellite link or television network (broadcast/cable). Web based conferencing: as the name implies, involves the transmission of text and graphic, audio and visual media via the Internet; it requires the use of a computer with a browser and communication can be both synchronous and asynchronous.

During the forum, presentations were made by Pacific regional representatives including USP, UNESCO Pacific Office and the Secretariat of the Pacific Community on the current status of ICT in education in the region. Professor Chandra made a presentation on ICT and its role at USP and the Pacific region. He was also a member of the panel discussion on issues in ICT in the Region. The donor presentations were focused on the importance of building teacher capacity in ICT in education. Best practices and case studies from the Caribbean region were also shared with the objective that they could possibly be re contextualized for the Pacific region. The presentations brought about engaging discussions amongst the delegates on experiences, challenges and opportunities of integrating ICT in education for the Pacific region. The discussions were extended through an online forum to continue to discuss issues raised at the forum.

Globalization and technological change processes that have accelerated in random over the past fifteen years have created a new global economy "powered by technology, fuelled by information and driven by knowledge." The emergence of this new global economy has serious implications for the nature and purpose of educational institutions. As the half life of information continues to shrink and access to information continues to grow exponentially, schools cannot remain mere venues for the transmission of a prescribed set of information from teacher to student over a fixed period of time. Rather, schools must promote "learning to learn," i.e., the acquisition of knowledge and skills that make possible continuous learning over the lifetime. "The illiterate of the 21stcentury," according to futurist Alvin Toffler," will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." Concerns over educational relevance and quality coexist with the imperative of expanding educational opportunities to those made most vulnerable by globalization developing countries in general; low-income groups, girls and women, and low skilled workers in

particular. Global changes also put pressure on all groups to constantly acquire and apply new skills. The International Labour Organization defines the requirements for education and training in the new global economy simply as "Basic Education for All", "Core Work Skills for All "and "Lifelong Learning for All". Information and communication technologies (ICTs) which include radio and television, as well as newer digital technologies such as computers and the Internet have been touted as potentially powerful enabling tools for educational change and reform. When used appropriately, different ICTs are said to help expand access to education, strengthen the relevance of education to the increasingly digital workplace, and raise educational quality by, among others, helping make teaching and learning into an engaging, active process connected to real life. However, the experience of introducing different ICTs in the classroom and other educational settings all over the world over the past several decades suggests that the full realization of the potential educational benefits of ICTs is not automatic. The effective integration of ICTs into the educational system is a complex, multifaceted process that involves not just technology indeed, given enough initial capital, getting the technology is the easiest part But also curriculum and pedagogy, institutional readiness, teacher competencies, and long term financing, among others.

ICT and Government Responsibilities

The basic objective and responsibility of any Government all over the world is to provide and avail quality education for all from elementary level to higher education. In our teaching learning process the core principle according to the national goal how to see the maximum output in the part of the learners. The principle of Instructional Technology (IT) and Learning Technology (LT) are associated with the Teachers, Teaching Environments and Learners' achievement. Intervention of technology in the teaching learning process as a result of Educational Technology is the product of instructional and learning process. In both IT and LT are more potential by the use of Information Communication Technology (ICT) for resolving the burning issues teaching learning process now a day. For many of us, the lure of computers is a powerful one. However, many of us also refrain from using computers for fear of failure. We want to hone computer skills, but are scared to make the effort because we lack those very skills. Too

many of us, especially in the field of learning, are caught in this modern tug of war. Better understandings by the applications of pedagogical issues related to learning process of the learner in any stages are the remarkable area for the educational problems. ICT in teaching learning process in both LT and IT trying to facilitates pedagogical issues with respect to other learning constraints of both learners and teachers. The emerging concept of media approach of teaching learning changed with the integration different media with single platform as Multi Media (MM) approaches of teaching learning.

Conclusion and Suggestions

In conclusion, this article demonstrates that the National Education Policy 2020 (NEP-2020) provides a comprehensive and forward-looking framework for transforming higher education in India through structural reform, technological integration, and pedagogical innovation. The analysis highlights that while the policy offers significant opportunities to enhance access, quality, and global competitiveness, its success is highly dependent on effective and context-sensitive implementation strategies.

From a policy perspective, the study emphasizes the need for stronger coordination among government agencies, higher education institutions, and relevant stakeholders to ensure inclusive and equitable development. Particular attention should be given to addressing persistent challenges, including digital literacy gaps, infrastructure disparities, and teacher preparedness, which remain critical barriers to reform implementation.

In terms of practical implications, institutions should prioritize continuous professional development, strengthen ICT integration, and adopt flexible and student-centered learning approaches aligned with NEP-2020. Furthermore, sustained public investment and institutional capacity building are essential to support long-term transformation.

Overall, the future of higher education in India will depend on the alignment between policy objectives and institutional practices, as well as the ability of the system to adapt to emerging educational and technological demands in a rapidly changing global context.

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A Gamified Mobile Telerehabilitation Framework for Improving Exercise Adherence in Older Adults

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Abstract

The efficacy of long-term rehabilitation programs is diminished by older persons' poor adherence to recommended rehabilitation exercises. Even though telerehabilitation has made rehabilitation services more accessible, many current systems still offer disjointed support, frequently handling clinical monitoring, exercise delivery, and motivation independently rather than in a single digital workflow. In order to improve exercise adherence, this study suggests a gamified mobile telerehabilitation framework for older persons that incorporates clinician-supervised monitoring, gamification, and rehabilitation management. The study uses the Design Science Research (DSR) methodology, emphasizing framework design, objective formulation, and problem identification. A centralized application server connects the patient, clinician, and system support modules that make up the suggested structure. This study's novelty innovation is the comprehensive fusion of gamification, adaptive rehabilitation, and ongoing clinical input into a unified telerehabilitation architecture created especially for senior citizens. A structured conceptual framework that links clinician decision-making, patient exercise activities, and motivational support systems into a single coordinated system is the main contribution. The problem formulation, design objectives, system architecture, use-case flow, and framework design serve as the basis for further prototype development, and the outcomes are currently conceptual rather than empirical. Consequently, this study does not report any empirical effectiveness outcomes. In order to assess the framework's potential to enhance exercise adherence, user engagement, and remote rehabilitation

monitoring, the next phases will involve UI/UX implementation, prototype development, demonstration, and evaluation.

Keywords: Telerehabilitation, Gamification, Older Adults, Exercise Adherence, Digital Health

Introduction

Healthcare systems are facing significant challenges as a result of the aging population, especially when it comes to delivering ongoing and efficient rehabilitation treatments. Chronic illnesses, functional decline, and mobility issues are increasingly common in older persons, all of which enhance the need for long-term rehabilitation to preserve independence and quality of life. Because it maintains functional capacity and encourages participation in daily life, rehabilitation is therefore a crucial part of good aging (WHO, 2021).

Over 29 million people in Indonesia are considered older adults, making up more than 10% of the country's overall population. The country's aging population is still growing (Central Bureau of Statistics of Indonesia, 2023). There is an increasing need for rehabilitation services since a significant section of this group suffers from functional impairments brought on by age-related decline, musculoskeletal problems, and chronic illness. Additionally, according to national health data, many older persons need ongoing therapy help due to limits in their everyday activities (Ministry of Health Indonesia, 2018). However, continuity of therapy is frequently challenging to maintain, and access to rehabilitation is still restricted, especially for older persons residing outside of major healthcare facilities.

Low adherence to recommended exercise regimens is one of the most enduring issues in rehabilitation. Due to poor motivation, inadequate supervision, and the repetitive nature of traditional therapy, many older persons do not regularly complete rehabilitation activities. Even though telerehabilitation has made rehabilitation more accessible by allowing it to take place outside of clinical settings, many current systems still provide insufficient assistance for long-term engagement, customized exercise adaption, and continuous clinician supervision. By converting monotonous rehabilitation chores into more engaging and fulfilling experiences, the incorporation of gamification into telerehabilitation

presents a viable approach to improve motivation, engagement, and adherence (Ambros-Antemate et al., 2023). Points, badges, challenges, and progress tracking are examples of gamification components that may promote continued engagement and make rehabilitation tasks less tedious for patients.

New chances to improve rehabilitation services through data-driven interventions, remote monitoring, and mobile applications have been made possible by recent developments in digital health technologies. Among these methods, gamification—which incorporates game-like elements including prizes, challenges, and progress indicators—has drawn more attention as a successful tactic to improve patient engagement (Edgardo, 2024). Additionally, prior research has demonstrated that by encouraging intrinsic motivation and offering prompt feedback, gamification might increase adherence to health interventions (Bai & Chen, 2025; Lopes et al., 2024).

The majority of telerehabilitation systems currently in use, however, handle exercise delivery, motivation, or clinical monitoring independently rather than combining these elements into a unified framework specifically designed for older persons, indicating a glaring research gap. Because of this, there is currently no organized framework for mobile telerehabilitation that integrates gamification, adaptive rehabilitation planning, and ongoing clinician-supervised monitoring into a single, cohesive system. Current digital rehabilitation options are less able to provide sustained patient engagement and long-term adherence as a result of this constraint. In order to incorporate clinical feedback, adaptive exercise management, and motivational techniques into a cohesive rehabilitation workflow, an integrated framework is required (Daniels et al., 2024).

In order to close this gap, this study proposes a gamified mobile telerehabilitation framework for senior citizens that combines clinical monitoring, gamification, and rehabilitation management into a single digital platform. The goal of the suggested framework is to facilitate adaptive rehabilitation, enhance patient motivation, support structured exercise delivery, and improve communication between patients, therapists, and doctors. In order to assure both theoretical relevance and practical applicability, this study employs a Design Science Research strategy to direct the methodical development of the framework.

The objectives of this study are as follows:

- To develop a gamified mobile telerehabilitation framework that integrates patient functions, clinical functions, and system support modules.

Three levels of contribution are made by this study. By offering an integrated conceptual framework that integrates gamification, adaptive therapy, and clinician-supervised monitoring for older adults—an area that has not been sufficiently united in other studies—it theoretically expands the telerehabilitation and digital health literature. In practical terms, the framework offers researchers, healthcare professionals, and rehabilitation providers an organized resource for creating rehabilitation workflows that can enhance patient involvement, increase exercise adherence, and facilitate remote clinical supervision. In terms of technology, the study offers a system architecture that links clinical, patient, and system support modules via a centralized application server. This provides a basis for further UI/UX design, prototype creation, and future deployment of scalable mobile telerehabilitation solutions.

Related Work

1. Telerehabilitation for Older Adults

Telerehabilitation is becoming more widely acknowledged as a viable approach to increase older persons' access to rehabilitation, particularly for those with musculoskeletal problems, chronic cardiac conditions, or mobility constraints. Physiotherapist-led, exercise-based telerehabilitation is typically safe, well-adhered to, and non-inferior to in-person rehabilitation for a number of functional outcomes in older persons, according to recent research. According to systematic evaluations, real-time telerehabilitation can achieve efficacy comparable to traditional rehabilitation while lowering travel barriers, and supervised telerehabilitation can enhance functional performance in older persons living in the community. The justification for scalable digital rehabilitation models is strengthened by the fact that telerehabilitation and telemedicine have demonstrated comparable clinical efficacy to in-person care in musculoskeletal care more generally and may also lower expenses (Wicks et al., 2023b).

2. Exercise Adherence as a Core Challenge

Exercise adherence is still one of the biggest obstacles to optimal rehabilitation outcomes for older persons and those with chronic diseases, despite advancements in rehabilitation technologies. A variety of elements, such as motivation, self-efficacy, feedback, program simplicity, supervision, and personalization, consistently influence adherence, according to umbrella and systematic reviews. This means that an effective telerehabilitation intervention must actively address behavioral engagement and sustained participation; technology delivery alone is insufficient. The importance of adherence to long-term recovery and functional reintegration is demonstrated by the identical treatment of adherence as a primary outcome in studies on stroke telerehabilitation (Collado-Mateo et al., 2021).

3. Gamification and Exergames in Rehabilitation

Gamification has been extensively researched as a way to boost perseverance, enjoyment, and involvement in health interventions. According to a basic comprehensive review, gamification can have a favourable impact on health-related behaviors, however the results differ according on behavioral processes and design quality. Reviews in the field of rehabilitation have demonstrated that gamified strategies and exergames can enhance motivation, engagement linked to adherence, and certain functional outcomes, such as balance, fall-associated metrics, and frailty-related indicators in older persons. Exergames have been shown to improve balance performance, balance self-efficacy, and fall prevention in older groups, including in long-term care facilities. These results imply that when gamification is incorporated into rehabilitation processes, it can serve as a potentially significant adherence-support mechanism rather than just an entertainment layer (Johnson et al., 2016).

4. Usability, Acceptance, and Older-Adult-Centered Design

Digital rehabilitation systems' acceptability, usefulness, and accessibility are critical to their effectiveness with older persons. Studies on exergame-based telerehabilitation for senior citizens have demonstrated that when these systems are straightforward, easily understood, customized, and bolstered by human interaction, both senior citizens and medical professionals are willing to interact with them. Focus-group studies also show that older persons are concerned about fall risk, technological

complexity, and social isolation, but they also value low cognitive strain, motivating variation, and relevance to health goals. Studies on the use and acceptability of more recent exergame-based telerehabilitation systems have shown promising outcomes, but they also demonstrate that context and implementation quality have a significant impact on perceived utility and enjoyment. These results underline the necessity of a user-centered framework as opposed to a platform that prioritizes technology (Seinsche et al., 2022).

5. Gap in the Current Literature

The research still demonstrates a fragmentation issue despite the encouraging data for telerehabilitation and the expanding potential of gamification. While some research emphasize gamified interaction without strong clinical monitoring, personalization, or interdisciplinary workflow integration, many others concentrate on clinical effectiveness without strong engagement design. Furthermore, discrepancies in digital literacy, access, and implementation in older-adult telerehabilitation have been brought to light by ethics and equity assessments, suggesting that technology viability on its own is insufficient. Thus, an integrated framework that concurrently integrates patient-facing mobile rehabilitation, clinician supervision, adaptive exercise planning, structured feedback loops, and gamification mechanisms specifically targeted at improving adherence is still required. The suggested structure targets this niche (Veras et al., 2025).

According to recent research, telerehabilitation for older persons is clinically feasible. Physiotherapist-led and guided programs provide non-inferior outcomes to in-person therapy for a number of functional measures, while also increasing accessibility and, in certain situations, lowering costs. However, the evidence repeatedly shows that motivation, self-efficacy, feedback, program simplicity, and personalization are the main obstacles to adherence. Simultaneously, research on gamification and exergames indicates that some rehabilitation outcomes, including balance, fall-related metrics, and frailty-related indicators in older populations, can be improved by gaming components. However, research on telerehabilitation for older adults also demonstrates that physician assistance, safety, usability, and simplicity are still essential for acceptability and long-term use. When considered collectively, the research demonstrates the potential of telerehabilitation and gamification, but it also highlights a lack of integrated frameworks

that integrate clinician monitoring, adherence-oriented gamification, adaptive rehabilitation planning, and older adult-centered usability into a single mobile telerehabilitation ecosystem (Wicks et al., 2023a).

Methodology

The framework development follows the Design Science Research (DSR) methodology, starting from problem identification and objective definition, followed by the design and development stage. The design phase includes requirement analysis, conceptual framework modeling, system architecture design, functional mapping, gamification integration, and prototype development. The resulting framework integrates rehabilitation management, gamification, and clinical monitoring into a unified telerehabilitation system. The DSR method is shown in Figure 1.

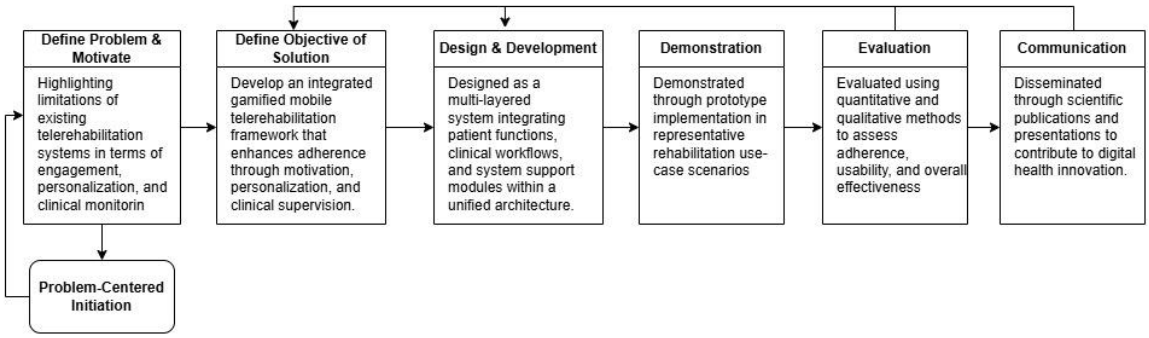


Figure 1. Design Science Research Methodoly (K. Peffers et al., 2007)

1. Problem-Centered Initiation

Problem-centered initiation is the first step in the Design Science Research method and acts as the study's entrance point. The main issue found in this study is older persons' poor adherence to recommended rehabilitation exercises, which has a substantial impact on long-term functional independence and recovery results. In addition to being identified through a review of the literature, this issue is also confirmed by insights from important stakeholders, such as medical technology lecturers, rehabilitation therapists who specialize in elder care, and medical technology students who have finished clinical internships in hospital rehabilitation departments. Rehabilitation therapists stressed that a lack of desire and inadequate supervision outside of clinical

settings are the main reasons why many older patients do not regularly adhere to exercise regimens. While students reported real-world observations of patient non-compliance during their hospital training, lecturers emphasized the gap between technological promise and its practical implementation in rehabilitation services. The significance of the highlighted issue is reinforced by these united viewpoints, which also support the necessity of an integrated digital solution.

Purposive sampling was used to choose stakeholders, who comprised medical technology instructors, rehabilitation therapists, and medical technology students who had completed clinical internships in hospital rehabilitation departments. They ensured that the suggested system is clinically relevant, technically possible, and in line with actual rehabilitation procedures by participating in problem identification, requirement analysis, and framework design.

2. Define Problem and Motivate

The highlighted issue is further examined and supported in the second step using both theoretical and empirical viewpoints. Existing telerehabilitation systems frequently lack engagement mechanisms, customisation features, and ongoing clinical monitoring, according to a thorough study of the literature. Stakeholder input supports these conclusions. According to rehabilitation specialists, the procedures in place do not enable customized exercise regimens or offer enough feedback to keep patients motivated. In order to close the gap between clinical needs and technical capabilities, medical technology lecturers stressed the significance of incorporating digital innovation, such as gamification and adaptive systems, into rehabilitation frameworks. Furthermore, students who interned in hospital rehabilitation units noted that the lack of interactive and interesting components caused many patients to lose interest in repetitious activities. In order to increase adherence and patient involvement, a novel framework that incorporates gamification, adaptive rehabilitation, and clinical monitoring is being developed.

3. Define Objectives of a Solution

The third step concentrates on identifying the goals of the suggested solution based on the problem analysis. The main goal is to create a gamified mobile telerehabilitation framework that improves older individuals' exercise adherence. The

selected stakeholders' feedback is incorporated into the formulation of this goal. The necessity of a system that enables ongoing monitoring and adaptable modification of exercise regimens based on patient performance was underlined by rehabilitation therapists. In order to enable scalable and sustainable healthcare solutions, lecturers offered insights on the integration of emerging technologies, such as intelligent systems and mobile health platforms. In the meantime, students emphasized the significance of simplicity and usability in system design, particularly for older persons with low levels of technical literacy. In order to boost motivation, the framework is built with gamification components including challenges, incentives, and progress tracking in addition to adaptive mechanisms that allow rehabilitation programs to be customized. The system also seeks to enable smooth communication and cooperation between physicians, therapists, and patients in a single digital setting.

4. Design and Development

Building the suggested artifact—the gamified mobile telerehabilitation framework—is the main goal of the design and development phase. Requirements gleaned from stakeholder input and literature serve as the basis for this step. Clinical requirements, including suitable workout structures, safety considerations, and monitoring parameters, are contributed by rehabilitation therapists. Medical technology lecturers offer advice on digital health technology integration, system architecture, and current research trends. During their hospital internships, students provide useful ideas about usability, interface design, and real-world workflow. These inputs are used to create a multi-layered architecture that includes a cloud-based backend system, a web-based dashboard for medical professionals, and a mobile application for patients. A monitoring module for tracking patient progress and facilitating feedback, a gamification engine for increasing engagement, and a rehabilitation engine for overseeing exercise regimens are examples of core modules. Additionally, the system includes adaptive mechanisms that enable rehabilitation regimens to be dynamically adjusted based on performance data. Iterative prototyping is used in the development process to ensure that the system design is continuously improved. This cooperative and multidisciplinary design process guarantees that the final framework is technologically sound, therapeutically applicable, and easy to use for senior citizens.

5. Demonstration, Evaluation, And Communication

After the UI/UX design phase is finished, the next phases of Design Science Research will be conducted, including development, demonstration, evaluation, and communication. Creating a working prototype of the gamified mobile telerehabilitation system from the planned framework and user interface will be the main goal of the development stage. Following the prototype's implementation, the system will be used in representative use-case scenarios involving patients, therapists, and physicians to demonstrate its practical operation. The system's efficacy, usability, and influence on exercise adherence will next be evaluated using both quantitative measures, such adherence rates and usability scores, and qualitative input from stakeholders. In order to provide accessibility and contribute to the advancement of digital health innovation, the communication stage will finally distribute the study findings and generated artifact through scientific papers and conferences.

After the UI/UX design and prototype are finished, empirical evaluation will be carried out in subsequent work. At that stage, the prototype will be tested with representative users, including older adults and relevant stakeholders. The System Usability Scale (SUS) will be used to evaluate the system's usability and user experience, including input from users to help make improvements.

Result

The proposed framework integrates clinician supervision, patient interaction, and digital health technology into a single system to address the serious problem of low exercise adherence among older persons in rehabilitation programs. This methodology integrates patient-centered mobile engagement with clinician-driven monitoring and adaptive decision-making, building on the Design Science Research approach and drawing from earlier research on telerehabilitation, gamification, and user-centered design. By incorporating motivational techniques like gamification into an organized rehabilitation workflow that is backed by real-time feedback and data-driven modifications, it seeks to close the gap between accessibility and engagement. The gamified mobile telerehabilitation framework's general architecture and interaction flow are depicted in the accompanying

picture (Figure 2), which also highlights the connections between patient activities, clinical procedures, and system-level support modules.

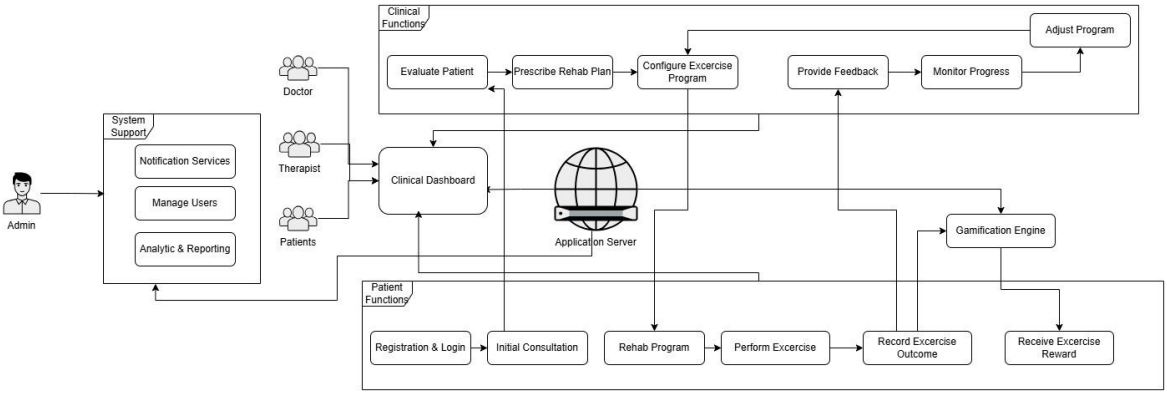


Figure 2. Gamified Rehabilitation and Telehealth Framework (GReaT Framework)

The proposed framework integrates clinician-facing decision support, administrator-managed system services, and patient-facing rehabilitation functions into a single digital platform to create a multi-user gamified mobile telerehabilitation environment for senior citizens. The framework is broadly divided into three main layers: system support, clinical functions, and patient functions, all of which are managed by an application server. This design is in line with earlier telerehabilitation research demonstrating that a strong digital backend to support continuity of care, clinician supervision, communication channels, and an exercise delivery interface are all necessary for successful remote rehabilitation for senior citizens. Recent research on exergame-based systems and telerehabilitation for older adults has demonstrated that when a platform integrates monitoring, guided at-home exercise, and basic user interaction into an integrated architecture, acceptance and feasibility increase (Seinsche et al., 2023).

The framework starts at the patient level with the Registration and Login module, which offers safe access to the system prior to the commencement of the rehabilitation process. Because digital rehabilitation for senior citizens must strike a balance between usability, access restriction, and individualized data keeping, this feature is crucial. Following authentication, patients move on to the Initial Consultation phase, during which their functional limitations, clinical condition, and rehabilitation requirements are determined. Access to the Rehab Program module, where recommended exercises are

presented in an organized and comprehensible manner, comes next. After that, the patient completes Exercise and Record Exercise Outcome, which enables the system to record symptoms, perceived effort, completion status, and other pertinent rehabilitative information. The practical requirement for home-based rehabilitation systems to enable exercise delivery as well as result reporting and adherence monitoring was noted in earlier research, and this sequence reflects that need. Prescribed exercise is beneficial, according to numerous studies on exercise adherence in older persons; nevertheless, adherence may be low unless the intervention is structured, observable, and sensitive to the patient's experience (Shaw et al., 2022).

The Gamification Engine, which is directly linked to the patient exercise workflow, is a key component of the suggested system. Exercise rewards, such as points, badges, progress markers, streaks, or challenges, provide the patient with reinforcement following exercise completion and outcome tracking. This design is based on the larger body of research on gamification, which shows that it can have a good impact on health-related behaviors, particularly when it boosts motivation, validates advancement, and offers quick feedback. Previous assessments, however, also warn that gamification is not always successful and that its effectiveness depends on closely aligning with the objectives and context of the user as well as theoretically informed design. Gamification is therefore viewed in this framework as an adherence-support tool that is integrated right into the rehabilitation cycle rather than as a stand-alone entertainment feature. This strategy is also in line with suggestions that gamified health systems be linked to actual behavior change goals and implemented through iterative co-development (Johnson et al., 2016).

The Clinical Dashboard, which serves as the primary professional interface for rehabilitation planning and monitoring, allows physicians and therapists to access the system at the clinical level. Evaluate Patient is the first step in the clinical workflow, where the doctor evaluates the patient's condition and preparedness for rehabilitation. The therapist or clinician can then Configure Exercise Program by converting the rehabilitation goals into practical exercise routines after the doctor utilizes Prescribe Rehab Plan to define the general therapeutic direction. Because previous research indicates that effective telerehabilitation systems must connect medical decision-making and practical day-to-day exercise delivery, this division between rehabilitation prescription

and exercise configuration is crucial. Clinicians use the Provide Feedback and Monitor Progress modules to assess workout results, monitor adherence, and pinpoint obstacles or safety concerns after the patient starts training. The physician can then modify the program as necessary, establishing an iterative feedback loop between program improvement and patient performance. The direction of recent telerehabilitation studies, which highlight that older-adult rehabilitation systems become more meaningful when they support clinician supervision, personalization, and timely adjustment rather than static exercise assignment alone, is reflected in this type of adaptive and monitored structure (Seinsche et al., 2023).

The admin role is the primary entry point to the system support layer that is part of the framework. Analytics and Reporting, Manage Users, and Notification Services are all included in this tier. Since organized cues and follow-up are frequently necessary for sustained involvement in older-adult adherence support, notification systems are crucial for providing reminders, progress prompts, and communication alerts. User management ensures that the system maintains proper authorization and workflow separation by controlling access roles for patients, physicians, therapists, and administrators. In the meantime, the analytics and reporting module compiles usage and rehabilitation data into summaries that system managers and clinicians can use. The addition of these support modules is in line with research demonstrating that telerehabilitation platforms require operational services that make the system scalable, maintainable, and clinically beneficial over time, in addition to a front-end exercise interface (Shaw et al., 2022).

The framework's integration core, the application server, links system-level services, gamification responses, clinical decisions, and patient actions. The framework facilitates an ongoing rehabilitation loop through this centralized orchestration: the patient completes exercises, results are documented, the gamification engine encourages involvement, clinicians assess progress and offer feedback, and the rehabilitation plan is modified as necessary. The primary gap found in related work is directly addressed by this cyclical approach. Few studies offer a cohesive model that integrates older-adult-centered access, clinician-supervised rehabilitation planning, structured exercise reporting, adaptive feedback, and adherence-oriented gamification within a single mobile telerehabilitation architecture. Existing studies support telerehabilitation, while other

studies separately support gamification or exergame-based rehabilitation. By combining these previously dispersed components into a single, well-coordinated system, the suggested framework aims to close that gap (Seinsche et al., 2023).

The study's findings demonstrate the originality of the suggested framework, which combines clinician-supervised monitoring, gamification, and adaptive rehabilitation into a single mobile telerehabilitation system for senior citizens. Prior research has demonstrated that telerehabilitation can enhance functional performance and be a viable substitute for in-person rehabilitation for older persons; nevertheless, these systems frequently prioritize distant delivery over adherence-oriented integration (Gamble et al., 2024; Johnson et al., 2016). Similarly, studies on exergame-based telerehabilitation have shown usability and technology acceptance among older users, and earlier work on gamification has reported positive effects on health-related behaviors; however, these approaches are typically implemented as separate or partially connected components (Gamble et al., 2024). The suggested framework, on the other hand, creates a continuous feedback loop that connects patient exercise activities, gamified motivation, and clinical decision-making. This approach tackles the well-known problem that behavioral, program-related, and supervision-related factors have a significant impact on adherence in older adults. Because it offers a structured basis for creating scalable, user-centered digital rehabilitation systems that are not only technologically feasible but also clinically relevant and better matched with the long-term adherence requirements of aging populations, this integrated design has significant implications for both research and practice (Edgardo, 2024; Seinsche et al., 2023).

Discussion

The suggested gamified mobile telerehabilitation framework integrates clinician-supervised monitoring, adaptive rehabilitation, and motivating mechanisms into a single solution to address the ongoing problem of low exercise adherence among older persons. The results of this study highlight the significance of integrating clinical procedures with behavioral engagement techniques rather than treating them as distinct elements. Along with practical suggestions, this part addresses the consequences of the suggested framework for research, clinical practice, and technology advancement.

a. Research Implications

This study emphasizes the necessity for more integrated approaches in digital rehabilitation systems from a research standpoint. Future studies should concentrate on multi-component frameworks that integrate engagement, personalization, and clinical monitoring rather than separate assessments of gamification or telerehabilitation. To assess how such frameworks affect exercise adherence and clinical outcomes, researchers are urged to carry out empirical validation studies, such as randomized controlled trials or longitudinal studies. In order to improve the design of gamification components and gain a deeper understanding of user motivation, future research should also investigate behavioral theories like the Health Belief Model and Self-Determination Theory. The creation of standardized evaluation criteria, such as adherence rate, engagement index, and usability scores, is another crucial avenue for benchmarking and cross-study comparability.

b. Clinical Implications

The suggested framework offers a structured methodology for incorporating telerehabilitation into regular care for senior citizens in clinical settings. It is advised that healthcare professionals use hybrid rehabilitation approaches that integrate digital exercise delivery, remote monitoring, and in-person assessment. To guarantee patient safety and maximize rehabilitation results, clinicians should actively utilize system features like real-time monitoring dashboards, feedback systems, and adaptive program adjustments. To increase patient engagement and commitment, rehabilitation therapists should also use motivating techniques like gamified rewards and progress tracking. To guarantee the efficient use of digital rehabilitation platforms and to facilitate the shift from traditional to technology-assisted rehabilitation services, training programs for healthcare workers are also required.

C. Technological Implications

The proposed framework provides a methodical approach for integrating telerehabilitation into routine clinical care for senior persons. Healthcare practitioners are recommended to employ hybrid rehabilitation techniques that include in-person evaluation, remote monitoring, and digital exercise delivery. Clinicians should actively use system features including real-time monitoring dashboards, feedback systems, and adaptive

program adjustments to ensure patient safety and optimize rehabilitation outcomes. Rehabilitation therapists should also employ motivating strategies like gamified rewards and progress tracking to boost patient commitment and involvement. Training programs for healthcare professionals are also necessary to ensure the effective use of digital rehabilitation platforms and to ease the transition from traditional to technology-assisted rehabilitation services.

Conclusion

This study proposes a gamified mobile telerehabilitation framework that combines clinical monitoring, gamification techniques, and rehabilitation delivery into a single digital system to enhance exercise adherence among older persons. The framework, which was created utilizing the Design Science Research (DSR) methodology, tackles the main shortcomings of current telerehabilitation methods, especially with regard to engagement, customization, and ongoing supervision. A mobile application for patients and a clinical dashboard for medical professionals support the system's essential elements, which include a rehabilitation engine, gamification engine, and monitoring module. The framework increases user motivation and encourages regular involvement by incorporating gamification features like challenges, prizes, and progress tracking. Adaptive mechanisms allow rehabilitation programs to be dynamically adjusted based on patient performance. This research is new because it integrates clinical workflows, gamified engagement, and adaptive rehabilitation into a coherent system that facilitates ongoing patient and physician feedback. After the UI/UX design and system prototype are implemented, the next phases of development, demonstration, and evaluation will be carried out. Future research will concentrate on empirical validation and the incorporation of cutting-edge technologies like wearable sensors and AI-based personalization to further improve system efficacy and scalability.

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