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The Mediating Effect of Knowledge Integration on the Relationship between Capability and Innovative Behaviour

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Abstract

One of the main success drivers of the Fourth Industrial Revolution is the integration of information technology and industry, which encourages innovation through collaboration between industry and academia. As a result, fostering innovative behaviour among undergraduates is essential for success in higher education throughout this revolution. The purpose of this study is to examine the direct effects of capability (leadership, technological literacy, interaction, knowledge sharing, and collaboration) on innovative behaviour and the indirect effect of knowledge integration's mediating role. Data from 3,230 undergraduates was collected and analysed. The provided hypotheses were validated using structural equation modelling, which demonstrated that capability significantly influenced the success of adopting innovative behaviour. Furthermore, we observed that knowledge sharing was the most powerful predictor. We also discovered that the intervening knowledge integration had an indirect effect, indicating the presence of a relationship between capability and innovative behaviour through this variable. When the direct and indirect effects were evaluated, the direct effect was substantially stronger than the indirect effect. The study's practical implications should focus strongly on promoting innovative behaviour and knowledge integration in the process of establishing appropriate educational programmes for universities. Furthermore, universities should develop strategies to encourage undergraduate students to share their knowledge and abilities with others since this improves performance and increases awareness of new prospects for innovation. In future research, we should include more educational institutions in our study, such as high schools, technical schools, and graduate students.

Keywords:

Capability;
Knowledge Integration;
Innovative Behaviour;
Industry 4.0;
Mediating Effect.

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1- Introduction

Since the beginning of the twenty-first century, the world has been experiencing the Fourth Industrial Revolution, also known as Industry 4.0 [1]. One of the main thrusts of this revolution is the integration of information technology and industry, inducing innovation through collaboration between industry and academia [2, 3]. In today's highly competitive business world, innovation is essential for long-term competitive sustainability and can contribute to improved organisational performance [4, 5]. Moreover, innovation enables the education system to adapt and make students more globally competitive [1, 3].

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For Industry 4.0 to be successful, academia and industry must develop strategies for industrial transformation by focusing on human resources [3, 6]. In addition, Higher Education Institutions (HEIs) must provide educational experiences that encourage students to adapt to future industry and job demands [7]. Moreover, the education sector must adapt to these needs [6, 8]. In the educational context, several studies have highlighted digitalisation as one of the most important ways to promote these goals [6, 9].

According to Industry 4.0, innovation has always been one of the most significant issues for developed countries, but it also has the potential to be highly destructive for developing countries if not appropriately handled [10]. Developing countries should therefore provide opportunities for learning, knowledge transfer, and capability-building for organisations, allowing them to transform their workforce's skill levels and wages in a variety of ways [11].

In this study, we examined the factors that can influence innovation from the standpoint of Thailand, which was placed third among developing Asian countries in the Global Innovation Index 2021. Moreover, Thailand is now trying to transform into a high-income, knowledge-based economy by emphasising research and development, science and technology, creative thinking, and innovation [12]. Thailand has developed a new economic model since 2017, Thailand 4.0, based on a complement to the developments associated with Industry 4.0 in the business world. This model emphasises a knowledge-based workforce and enhances competitiveness in organisations that are dependent on innovation [12]. According to Buasuwan [13], Thailand should develop learning networks, public and private sector engagement, learners' mindsets, faculty and student skills, and new technologies to implement Industry 4.0 successfully. However, this challenge presents an opportunity for the educational systems in developing countries that currently lack workforces with the desired skills to take advantage of Industry 4.0 [14]. As a result, we are particularly interested in the educational context in which undergraduates in a developing Asian country such as Thailand are prepared to face the challenges of Industry 4.0.

However, there is limited theoretical research on the concept of knowledge integration on innovative behaviour in universities of developing Asian countries. Therefore, research on knowledge integration in innovative behaviour has the potential for further academic exploration. Firstly, we conducted a preliminary review of the factors that influence innovative behaviour and found that five dimensions of capability are crucial: leadership, technological literacy, interaction, knowledge sharing, and collaboration. Moreover, some studies signalled knowledge integration was an important mediating process as it connects diverse types of knowledge and capability across functions and teams, initiating innovation within an organisation. However, although several studies addressed knowledge integration and its mediating role as an influencer of innovation in organisations and the enterprise sector, there are no studies in the educational context. Hence, the objective of this paper is to investigate the effects of capability (leadership, technological literacy, interaction, knowledge sharing, and collaboration) and the mediating role of knowledge integration on the innovative behaviour of undergraduates.

By seeking to understand innovative behaviour, capability and knowledge integration influencing it, a quantitative approach was applied in this study to explore the variables involved. Structural Equation Modelling (SEM) was used to test the hypotheses and analyse the relationships among the factors. The study considers the insights of undergraduates from various universities in Thailand concerning the capability and knowledge integration factor of innovative behaviour. We believe that those factors are important for promoting innovative behaviour in universities. Therefore, the results of this study could be used as guidance for designing curriculum development in universities of developing Asian countries.

The remainder of the paper is structured as follows. Section 2 provides a literature review focused on capability, knowledge integration, innovative behaviour, and research approach. Section 3 describes the methods employed in this study for sample selection, data collection, measurement, and analysis. Section 4 reports the data analysis and results. Section 5 discusses the consequences of the findings. Finally, section 6 presents the study's conclusion, limitations, and recommendations for further research.

2- Literature Review and Hypotheses

This study employed five dimensions of capability: leadership, technological literacy, interaction, knowledge sharing, and collaboration.

2-1- Leadership

Leadership has been described by Hughes, et al. [15] as a manner of interaction that seeks to achieve positive change and increases organisational effectiveness and performance. Maria Stock, et al. [16] recommended that organisations establish strategies and guidelines for leadership development among employees, while Muenjohn, et al. [5] noted that leadership is critical to a firm's potential for innovation, and therefore indirectly influences its success.

Hoch [17] investigated the relationship between leadership and innovative behaviour in two different companies and found that shared and vertical leadership structures were positively related to the level of innovative behaviour in teams. Meanwhile, in the context of higher education, Al-Husseini and Elbeltagi [18] found that academic staff's perceptions

of leadership positively affect their creativity, and the quality of leadership significantly impacts product and process innovation in Iranian HEIs. In public universities in Iran, good leadership has a positive direct effect on innovation and an indirect positive effect through the mediating role of knowledge sharing [19].

2-2- Technological Literacy

Technological literacy allows for the application of rational scientific knowledge in various forms, such as tools, methodology, and systems that are created and interpreted to assist people in achieving specific goals [20]. Organisations should understand and manage innovation by integrating marketing activities, technology, and organisational change to successfully improve their business competitiveness [21, 22].

Additionally, the importance of technology in the transformation of HEIs should be highlighted because it will play an essential role in increasing students' comprehension of educational courses such as e-learning and computer-supported collaborative learning [23]. Therefore, HEIs should provide knowledge that enables students to understand and improve technical and innovation skills, which will be required when they are employed by organisations [8].

2-3- Interaction

Interaction is the flow of information between individuals or departments through activities such as face-to-face meetings or electronic communications [24]. Knowledge interaction is the direct and indirect exchange of personal and non-personal knowledge components between individuals and organisations to synthesise and apply knowledge in the innovation development process [25].

In their literature review, Shang, et al. [26] examined the effects of knowledge interaction on different types of business innovation. They discovered that the content and quality of knowledge gained through interaction with external stakeholders such as customers and employees within the organisation are key factors in building innovative capability. Similarly, Liu [27] states that interaction orientation significantly influences service innovation. Li and Liu [28] found that social interaction influences desired innovation outcomes in organisations by improving communication among employees so that they feel supported.

2-4- Knowledge Sharing

As part of knowledge management, knowledge sharing is a fundamental activity that enables innovation [29]. The interactive process of exchanging tacit and explicit knowledge among individuals or groups is characterised as knowledge sharing [30]. Individuals exchange information, experience, skills, and knowledge-related tasks [31]. One aspect of team knowledge sharing is exchanging information and ideas among team members, allowing relevant knowledge to be collected, stored, and retrieved [32, 33].

Organisational factors such as compensation systems that assist companies in accessing the tacit knowledge of company employees and transforming it into explicit knowledge can encourage knowledge sharing. While it has been discovered that sharing explicit knowledge has a greater influence on innovation pace and financial success, sharing tacit knowledge has a greater impact on innovation quality and operational performance [29]. According to some studies, knowledge-sharing activities can provide the opportunity for organisations to produce new ideas and foster innovative behaviour [34, 35]. Investigating the influence of knowledge sharing on product and process innovation in education, Al-Husseini and Elbeltagi [36] concluded that knowledge sharing plays a pivotal role in product and process innovation among academic teaching staff in public and private higher education institutions in Iraq, leading to increased innovation.

2-5- Collaboration

Collaboration is an information and communication process in which individuals interact and coordinate with other individuals or groups [37, 38]. Blomqvist and Levy [39] describe it as the transfer of knowledge between groups or teams by promoting collaborative behaviour when all the relevant members are gathered; the results should encompass all relevant activities and focus on achieving specific organisational goals. Moreover, the main benefit of collaboration is building and strengthening the long-term relationships among individuals within an organisation [37].

While numerous studies have shown that internal collaboration is a factor in a firm's innovation development, the external collaboration between firms and other stakeholders, such as universities, the public sector, customers, and R&D institutions, also affects innovation performance and increases competitive advantage [40]. Rodríguez, et al. [41] examined the impact of international collaboration on innovation in knowledge-intensive business services, suggesting that the benefits of international collaboration depend on the geographical location of a particular service enterprise, demonstrating that collaboration is essential for knowledge-intensive services because of the existing relationship between investors and professional knowledge providers. Kim and Rhee [42] have demonstrated that this reduces coordination costs and mitigates uncertainties in technological innovation.

We hypothesised that the development of the five dimensions of capability positively influences innovative behaviour among undergraduates (H1).

2-6- Capability and Knowledge Integration

In this study, knowledge integration is conceptualised as the dynamic capability to combine, structure, and apply different types of knowledge, such as practical, every day, and academic knowledge, with each of these representing a different disciplinary perspective [43]. Knowledge integration is considered central to the successful development of independent learning; it affords undergraduates the skills to generate new ideas, positioning them favourably in specific markets [44]. The importance of undergraduates' knowledge integration capability is described as follows:

First, leadership encourages team members to be confident and participate in decision-making. Moreover, leadership enhances innovation and organisational performance by integrating knowledge, culture, and strategy across teams [45-47].

Second, in the joint development of information technology projects, companies integrate internal and external knowledge to innovate products and processes. Therefore, the integrative capability is a key method for realising technology-related projects [48-50].

Third, Sun, et al. [51] show that social interaction propagates diverse knowledge from different sources and explains showed that social interaction propagates diverse knowledge from different sources and explains how new ideas are generated and integrated while managing the increasing complexity of knowledge in crowd-based collaborations for innovation. Additionally, Huang and Li [52] indicate that social interaction is positively related to knowledge management in innovation and builds an understanding of how knowledge management mediates the relationship between social interaction and innovation performance. Therefore, interaction is a key factor influencing organisational innovation performance.

Knowledge sharing can promote the integration of the company's internal and external knowledge of customers, suppliers, and partners. Moreover, the implementation of product development processes produces effective and proactive methods for knowledge sharing and integration among team members. Therefore, knowledge-sharing promotes innovation in organisational performance by instituting a knowledge integration framework that includes the organisation and its partners [53-55].

Finally, collaborating with multiple project teams within and outside the organisation encourages the integration of knowledge from different sources. This mechanism is an essential aspect of new product development and facilitates competitive advantage [56-58].

Building the capabilities of undergraduates can facilitate the timely integration of knowledge and promote the knowledge diversity required for innovative behaviour in higher education. We hypothesised that capability has a positive relationship with knowledge integration (H2).

2-7- Knowledge Integration and Innovative Behaviour

Grant [44] explained that knowledge integration requires individuals to transfer and share tacit and explicit knowledge across teams, departments, and organisations. Individuals thereby apply knowledge to their respective tasks to solve problems. However, knowledge integration is a transformational process, wherein knowledge is collected from diverse sources and added to an organisation's knowledge-based resources [59, 60]. It is also a process of combining diverse knowledge types and applying them to develop and introduce new products, services, and innovations [57, 61]. Organisations can apply effective knowledge and system integration to create more opportunities and develop long-term innovation and competitive strategies [46, 62, and 63]. Additionally, success depends on identifying how multidisciplinary teams use new and prior knowledge to internally create and source relevant knowledge and information externally [46, 58, and 61]. Accordingly, we hypothesised that knowledge integration positively influences innovative behaviour (H3).

2-8- The Mediating Effect of Knowledge Integration

H2 and H3 link capability and knowledge integration (through knowledge integration effects) to innovative behaviour. Previous studies have highlighted that integrating tacit and explicit knowledge across organisational boundaries is an important factor in influencing innovation outcomes within organisations [64-66].

However, limited attention has been paid to the mediating role of knowledge integration. We argue that knowledge integration plays a mediating role in the relationship between capability and innovative behaviour. The direct effect of capability on innovative behaviour can be mitigated by considering the indirect effect of capability on knowledge integration in the context of higher education. We hypothesised that knowledge integration positively mediates the relationship between capability and innovative behaviour (H4).

2-9- Research Purpose

We examined the relationship between capability and innovative behaviour in undergraduates in Thailand. Our model represents our hypothesis that capability influences innovative behaviour among undergraduates both directly and indirectly by influencing knowledge integration (Figure 1).

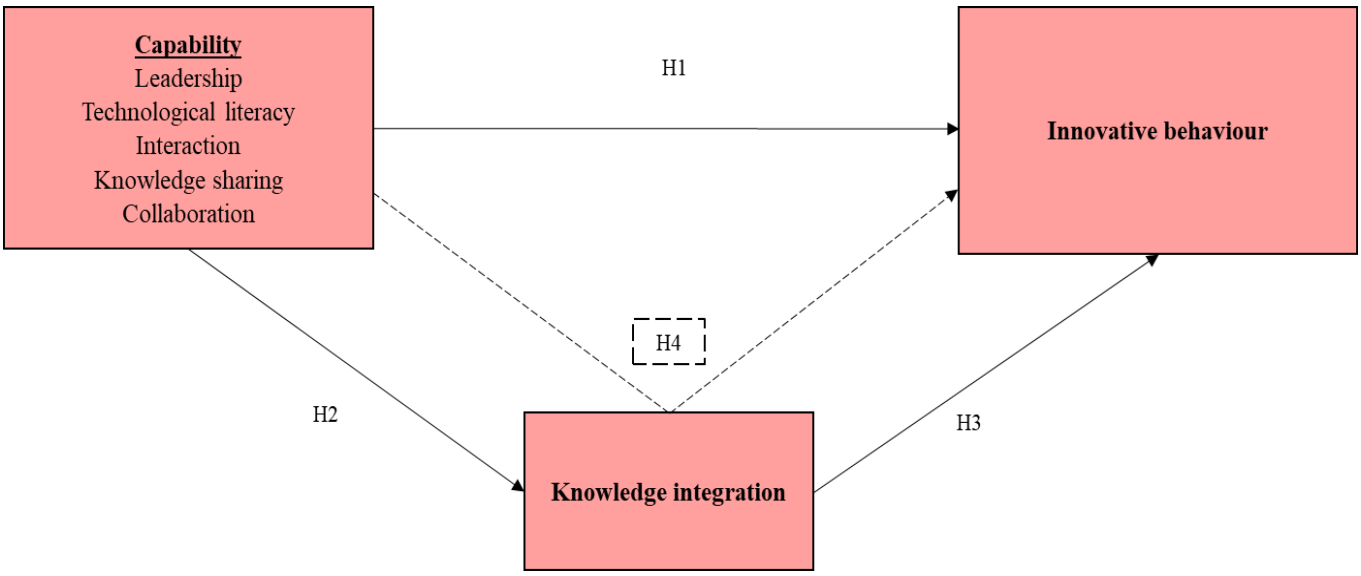

Figure 1. The hypothesised model

3- Materials and Methods

3-1- Data and Sample

In this study, we used a multi-stage sampling design to survey undergraduates' attitudes in Thailand and examined the direct and indirect effects of capability on innovative behaviour through knowledge integration. As of 2021, there were 155 universities under the Ministry of Higher Education, Science, Research, and Innovation. First-stage sampling included a purposive sample of universities, which have their administration and financing system for self-governance and full autonomy, enabling the university to make administrative and management decisions. We found that there were 26 such universities in Thailand. The second stage of sample selection was drawn from undergraduate education faculties across 13 universities in Thailand.

Beginning in 2021, 3,900 questionnaires were randomly distributed via letters and emails to the participants who were in the fourth and fifth years of their university studies. We ensured that the respondents were properly informed of the background, objective, and findings used in this study and provided their consent before taking part in the research survey. There were 3,500 completed questionnaires; the analysis used 3,230 responses, after eliminating questionnaires with insufficient data.

3-2- Instruments

In this study, we separated the questionnaire survey into two parts. The purpose of the first section was to collect personal information. In the second section, we assessed the participants regarding the five dimensions of capability (leadership, technological literacy, interaction, knowledge sharing, and collaboration), knowledge integration, and innovative behaviour. Appendix I illustrates the questionnaire survey used in this study.

3-3- Measures

All constructs and measurement scales were adopted and adapted from existing literature as shown in Table 3. These items were rated on a five-point Likert scale ranging from 'strongly disagree' (1) to 'strongly agree' (5).

3-4- Data Analysis

First, we used Cronbach's alpha (α) to examine the reliability of each item. Scores exceeded 0.70 in each case, establishing that the measures were reliable and internally consistent [67]. We then conducted composite reliability (CR) and average variance extracted (AVE) analyses to assess convergent validity. We obtained a CR value greater than 0.6 for all measurement questions. An AVE value greater than 0.5 indicates that the measurement questions accurately reflect the characteristics of each research variable in the model [68]. Descriptive statistics (mean and standard deviation) of all variables were calculated using SPSS 28.

LISREL 8.80 software indicated the robustness of fit in the SEM analysis. The goodness-of-fit indices (GFI) used in the study were the normed fit index (NFI), comparative fit index (CFI), adjusted goodness of fit index (AGFI), root mean square residual (RMR), and root mean square error of approximation (RMSEA). According to the literature on SEM, data fit is excellent when the NFI, CFI, GFI, and AGFI are greater than 0.95. For RMR and RMSEA, an excellent data fit requires values less than 0.05, and an acceptable fit requires values of less than 0.08 [67, 69]. Figure 2 represents the research methodology.

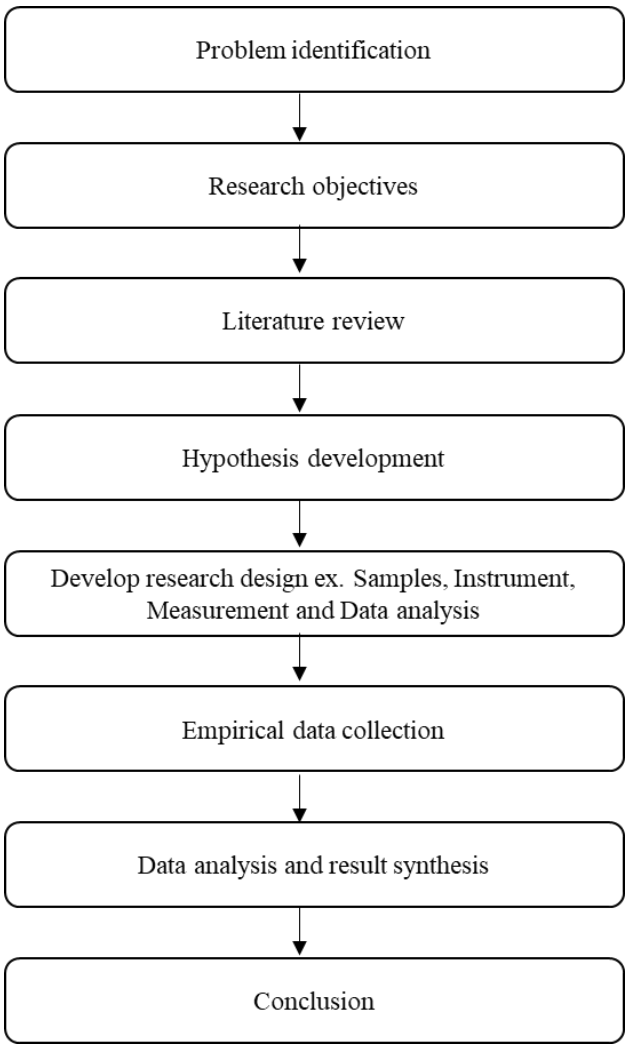

Figure 2. Flow chart of the research methodology

4- Results

We examined the effects of capability, both direct and indirect (via the mediating role of knowledge integration), on the innovative behaviour of undergraduates in Thailand. We utilised SEM to illustrate the effect relationships among variables by analysing the questionnaire responses and developed a measurement model to assess the convergent validity of our constructs, as well as a structural model to examine the direct and indirect impacts of capability.

4-1- Demographic Characteristics of Samples

3,900 questionnaires were employed to gather the data in this study. After screening and validation, 3,230 valid survey questionnaires in total were selected for further analysis. Hence, the actual response rate was 82.82%. Table 1 represents the demographic findings. The sample population was predominantly female (72.80%), with an average age of 22 years (48.42%). Most respondents were in their fourth year of study (76.41%).

Table 1. Questionnaires respondent profiles

Construct	item	Frequency	Percentage (%)
Gender	Male	880	27.2
	Female	2,350	72.8
Age	20	44	1.36
	21	1,139	35.26
	22	1,564	48.42
	23	429	13.28
	24	43	1.33
	25	11	0.34

College year	1	24	0.74
	2	5	0.15
	3	16	0.49
	4	2,468	76.41
	5	713	22.07
	6	4	0.12

Note: N = 3,230; missing values are not present in the table.

4-2- Descriptive Statistics and Correlations

The descriptive statistics and correlations of all the variables are shown in Table 2. All correlations were significant and positive between all the variables investigated.

Table 2. Mean, standard deviation (SD), and correlations

Constructs	Mean	SD	1	2	3
1. Innovative behaviour	3.819	0.590	1.000		
2. Knowledge integration	3.746	0.582	0.697**	1.000	
3. Capability	3.931	0.484	0.730**	0.705**	1.000

Note: N = 3,230, **P<0.01.

4-3- Analysis of Measurement Model

Confirmatory factor analysis has been conducted to validate this study's structure of a set of observed variables. The acceptability of the measurement model was assessed by the reliability of individual items, the internal consistency between items, and the model's convergent and discriminant validity. The overall goodness of fit analysis has been conducted for the model, whereas separate tests have been conducted for its significance in determining the assumed relationships between the different variables. The model comprised three constructs and 28 individual items. Table 3 shows the prominent indicators of the current study's measurement model (the factor loadings, Cronbach's alpha, CR, and AVE.).

Cronbach's alpha values range from 0.832 to 0.898 for each construct and its subsequent subscales, as shown in Table 3. This number is more than 0.7 and measures the reliability of variables in the model. As a result, the model's structures have attained internal consistency. Furthermore, the constructs' convergent and discriminant validity have been assessed. The former's validity is evaluated using two indices: composite reliability (CR) and average variance extracted (AVE), with values more than 0.6 and 0.5, respectively. For each construct, the CR value varies from 0.830 to 0.895. As a result, the inherent consistency of all measurement questions is higher. Finally, AVE ranges from 0.341 to 0.517, indicating that the measurement questions are unable to accurately capture the characteristics of each study variable in the model. However, if AVE is less than 0.5 but composite reliability is more than 0.6, the construct's convergent validity is still appropriate to assess the structural model [68].

Table 3. Summary of measurement results

Constructs	Adapted from	Factor loading	α	CR	AVE
Capability					
Leadership					
You help others create educational materials by giving advice. (LEAD1)	Al-Husseini, et al. [19] Maria Stock, et al. [16] Muenjohn, et al. [5]	0.450			
You encourage group members to share new ideas. (LEAD2)		0.465			
You instruct your team members on both positive and bad working practices. (LEAD3)		0.447			
Technological literacy			**0.898**	**0.883**	**0.341**
You search for information on developing educational materials using information technology. (TECH1)	Carroll [20] Lee and Kim [22] Li, et al. [64]	0.475			
You utilise technology to exchange knowledge. (TECH2)		0.501			
You apply information technology to produce educational materials. (TECH3)		0.498			
Interaction					
You communicate with the team. (INTER1)	Shang, et al. [26]	0.669			

You meet people from various groups. (INTER2)	Li and Liu [28] Liu [27]	0.659			
You always exchange knowledge with others. (INTER3)		0.644			
Knowledge Sharing					
You share your existing knowledge with others. (KS1)	Al-Husseini, et al. [19] Lapsomboonkamol, et al. [70] Wang and Hu [35]	0.630			
When you learn new knowledge, you share it with others. (KS2)		0.619			
You share your experience with others. (KS3)		0.668			
Collaboration					
When you disagree with a teammate, you can work together to resolve the conflict. (COLL1)	Wang and Hu [35] Un, et al. [40] Su, et al. [66]	0.657			
You have an open discussion with your team. (COLL2)		0.644			
You appropriately assign tasks to your team. (COLL3)		0.630			
Knowledge Integration					
You understand the interrelationship of two or more concepts. (KI1)	Guo, et al. [62] Li, et al. [64] Singh and Power [54]	0.745	**0.832**	**0.830**	**0.499**
Technology can help you be more productive. (KI2)		0.753			
You combine your ideas with those of others. (KI3)		0.836			
You explore the different contexts and apply concepts to each. (KI4)		0.600			
You link related and unrelated ideas. (KI5)		0.560			
Innovative behaviours					
You solve problems by analysing them. (INB1)	Al-Husseini, et al. [19] Bettencourt, et al. [4] Hughes, et al. [15] Su, et al. [66] Liu [27]	0.665	**0.895**	**0.895**	**0.517**
You devise new ideas. (INB2)		0.713			
You are an expert in information technology. (INB3)		0.667			
You build a network to assist you in generating new ideas. (INB4)		0.741			
You use knowledge to make new inventions. (INB5)		0.792			
Others can utilise your instructional materials. (INB6)		0.729			
You have an innovative method for developing educational materials. (INB7)		0.739			
You can evaluate and select educational materials. (INB8)		0.695			

Note: CR, composite reliability; AVE, average variance extracted

4-4- Structural Model

In terms of convergent and divergent validity, the results achieved a satisfactory level of construct validity. This result suggests that the constructs of the model are adequately suited to evaluate the structural model. The basic indices of the model fit are χ^2/df, NFI, CFI, GFI, AGFI, RMR, and RMSEA. As shown in Table 4, the goodness-of-fit indices gave adequate levels of fit for the model. As a result, an acceptable fit between the sample data and the hypothesized model is validated, allowing for further testing of hypotheses and evaluation of the structural model.

Table 4. Overall fit indices of the confirmatory factor analysis

Fit index	Capability	Knowledge integration	Innovative behaviour	Recommended criteria
χ^2/df	2.776	0.645	2.081	≤ 2–5
RMSEA	0.023	0.000	0.013	< 0.05–0.08
RMR	0.017	0.003	0.006	< 0.05–0.08
GFI	0.993	1.000	0.999	> 0.95
AGFI	0.986	0.999	0.994	> 0.95
NFI	0.997	1.000	0.999	> 0.95
CFI	0.998	1.000	1.000	> 0.95

Note: AGFI, adjusted goodness of fit index; CFI, comparative fit index (CFI); GFI, goodness-of-fit indices; NFI. normed fit index; RMR, root mean square residual; RMSEA, root mean square error of approximation.

After validating the measurement model, the structural model has been assessed by testing the hypotheses underlying the proposed research model. Path analysis has been performed to assess the causal relationships between constructs. The goodness-of-fit indicators of this model were χ^2= 747.93, df = 246, χ^2/df = 3.04, p = 0.000, NFI = 0.996, CFI = 0.997, GFI = 0.983, AGFI = 0.972, RMR = 0.0234, and RMSEA = 0.0259. The cut-off values were met by all the indicators, which indicates the model is an appropriate fit. Table 5 provides a summary of the results of testing for this study's first three hypotheses and shows the significance of relationships between the variables. The direct effects of SEM results are statistically significant and congruent with the hypothesised model.

Table 5. Hypotheses direct paths' effects

Hypothesis	Direct path	Estimation	T-value	Result
H1	Capability → innovative behaviour	0.788**	16.229	Supported
H2	Capability → knowledge integration	0.877**	37.151	Supported
H3	Knowledge integration → innovative behaviour	0.125*	2.679	Supported
Goodness of Fit Index	χ^2= 747.93, df = 246, χ^2/df = 3.04, p = 0.000, NFI = 0.996, CFI = 0.997, GFI = 0.983, AGFI = 0.972, RMR = 0.0234, and RMSEA = 0.0259			

Notes: *p < 0.01, **p < 0.001

Note: AGFI, adjusted goodness of fit index; CFI, comparative fit index (CFI); GFI, goodness-of-fit indices; NFI. normed fit index; RMR, root mean square residual; RMSEA, root mean square error of approximation

H1 concerned the effect of capability on innovative behaviour. Table 4 shows a parameter value of 0.788 (p < 0.001) for this effect; therefore, H1 was fully supported.

H2 focused on the direct effect of capability on knowledge integration. The statistically significant effect size of 0.877 (p < 0.001) listed in Table 4 validates H2.

The size of the effect of knowledge integration on innovative behaviour was (p < 0.01); this value was significant, supporting H3.

4-5- Mediation Analysis

Based on the 3,230 sampling units in the research model, a structural model was developed to investigate the mediation effect of knowledge integration, as shown in Figure 3. The path analysis results showed that knowledge integration had a positive mediation effect on the relationship between capability and innovative behaviour, supporting H4. Both the direct and indirect effects of capability on innovative behaviour were significant. Additionally, the effect of H4 (0.110) was smaller than the direct effect of H1 (0.788). Table 6 presents hypothesised paths' direct, indirect, and total effects.

Table 6. Hypothesised paths' direct, indirect, and total effects

Hypothesis	Path	Effect	Estimation	Total Effect
H1	Capability → innovative behaviour	Direct	0.788	0.898
H4	Capability → knowledge integration → innovative behaviour	Indirect	0.110	

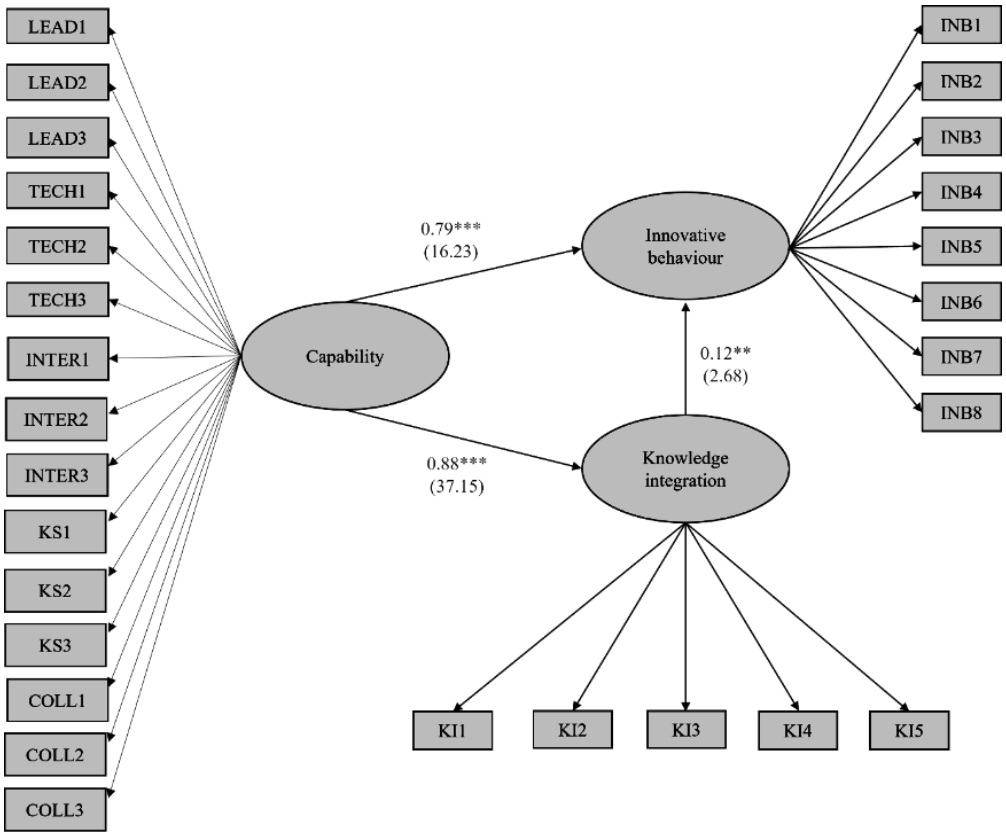

Figure 3. Results of SEM ***(Note: **p < 0.01, ***p < 0.001)***

4-6- Regression Analysis

Table 7 shows the results of stepwise multiple regression analysis and comparison of the direct effect of capability on innovative behaviour among Thai students.

Table 7. Multiple regressions of innovative behaviour on focal predictors

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
	β	*β*	*β*	*β*	*β*
Constant	1.438	0.729	0.481	0.317	0.288
Knowledge sharing	0.609***	0.429***	0.360***	0.291***	0.277***
Leadership		0.378***	0.280***	0.276***	0.271***
Technological literacy			0.227***	0.200***	0.194***
Collaboration				0.136***	0.117***
Interaction					0.050**
R^2	0.399	0.505	0.542	0.555	0.557
Adjusted R^2	0.398	0.504	0.541	0.555	0.556
F for change in R^2	2079.170	1597.525	1234.720	977.893	786.895

Note: **p<0.01, ***p<0.001

The findings in Table 7 reveal that all models significantly explained variance in innovative behaviour beyond the effects of known predictors (knowledge sharing, leadership, technology, collaboration, and interaction) at $p < 0.001$. We found that Model 5 provided the best fit to the data, with an R2 value of 0.557. In Model 5, knowledge sharing, leadership, technology, and collaboration were positively related to innovative behaviour ($p < 0.001$), as was interaction ($p < 0.01$). Finally, a comparison of the independent variables indicated that knowledge sharing had the greatest unique contribution to innovative behaviour ($\beta = 0.277$, $p < 0.001$). Next predictors of the variables are leadership ($\beta = 0.271$, $p < 0.001$), Technological literacy ($\beta = 0.194$, $p < 0.001$), Collaboration ($\beta = 0.117$, $p < 0.001$) and Interaction ($\beta = 0.050$, $p < 0.01$), respectively.

5- Discussion

The current study examined the effects of capability on innovative behaviour to close this research gap. Additionally, it has also investigated the role of knowledge integration as a mediator in the relationships between capability and innovative behaviour. Based on the data collection of 3,230 undergraduates, the considerable positive influence of capability (leadership, technological literacy, interaction, knowledge sharing and collaboration) on innovative behaviour was demonstrated, consistent with prior research.

First, we discovered that most students offered guidance to others, shared new ideas, and provided feedback on their working methods, which improved their innovative behaviour. Thus, the leadership positively influences innovative behaviour aligning with the findings of Al-Husseini and Elbeltagi [18] and Al-Husseini, et al. [19]. They found that the leadership of academic staffs, teaching staffs and leaders in the universities played a pivotal role in enhancing product and process innovation. Moreover, the result also confirms the finding from Hoch [17] regarding a positive direct effect of leadership on innovation in universities. Shared and vertical leadership of the working teams from different companies was positively associated with the teams' level of innovative behaviour.

Second, we found that students used IT tools to seek information and technologies to develop new functions and applications. It means that technological literacy positively influences innovative behaviour. This result agrees with the findings of Wu and Liu [8] who recognised that universities should provide and improve students' technological knowledge and skills, as these were driving forces for influencing innovative behaviour in organisations.

Third, we realized that the students had positive relationships with their teammates and other groups, and they shared their existing knowledge and experiences with others. This finding is consistent with the findings of Shang, et al. [26], who discovered that product innovation necessitates both broad and deep interaction between customers and technological knowledge, that problem-solving innovation necessitates either broad or deeper interaction between customers and technological knowledge, and that broad knowledge interaction is the most important driver for developing general innovation capability. Additionally, this research conclusion is consistent with Liu [27] earlier research, which concluded that interaction orientation is a critical component impacting the development of joint innovation competence and cross-functional information dissemination competence.

Of all the aspects, it was the fourth, knowledge sharing, that we found to be the strongest determinant of innovative behaviour. This finding was also reported by Vandavasi, et al. [34], who suggested that knowledge sharing supports the occurrence of shared leadership, leading to an increase in innovative behaviour among team members. Additionally, the

result also confirms the results from Wang and Wang [29] who found that both explicit and tacit knowledge-sharing practices not only have a positive relationship with performance directly but also influence innovation which in turn contributes to firm performance.

Last, we identified that when students collaborate, they had open conversations to find answers and develop new things, which encourages their innovative behaviours. This finding supports the results of Kim and Rhee [42], who demonstrated that collaboration among inventors and complementary knowledge experts necessitates knowledge boundary management and the integration of specialised activities toward technological innovation. Furthermore, the results supported the conclusions of Rodríguez, et al. [41]. They suggested that the nature of knowledge and innovation processes in professional and technological knowledge-intensive business services could explain the differences in the effects of international collaboration on innovation performance. Diversity in international collaboration, on the other hand, is more vital for innovation in technologically knowledge-intensive services.

For the knowledge integration, we discovered that undergraduates understood how to synthesise numerous concepts and employ them to improve productivity and innovative behaviour. This study provides support to the idea that knowledge integration has a considerable and positive effect on innovative behaviour. As a result, the finding is in accordance with earlier studies [46, 55, 62]. Jiang and Chen [46] discussed the significance of transformational leadership's integration role in enabling collaborative innovation of project teams in organisations. Guo, et al. [62] also agreed that both coordinated and systematic knowledge integration had positive effects on high-tech new venture performance and product innovation from the standpoint of entrepreneurs and senior executives. Furthermore, Wu, et al. [55] stated that developing knowledge integration and sharing method among geographically distributed teams and developers was a key issue and had a significant positive impact on the success of the product innovation development process in the enterprise.

Furthermore, we investigated knowledge integration as a mediating variable of the association between capability and innovative behaviour. The mediation hypothesis results reveal that knowledge integration positively impacts the relationship between capability and innovative behaviour, which is consistent with the previous research [64, 65]. Li, et al. [64] discovered that IT-driven knowledge competence has a strong positive influence on enterprise breakthrough innovation through enterprise knowledge integration in manufacturing enterprises and that the organisational task environment effectively regulates this impact relationship. Furthermore, knowledge integration mediated the relationship between market orientation, resource complementarity, information sharing, and product innovation performance [46].

5-1- Theoretical Implications

This study adds to the pedagogical literature in several ways. First, we extend the understanding of the relationship between capability (leadership, technological literacy, interaction, knowledge sharing, and collaboration) and innovative behaviour in the educational context, especially in Thailand. The results are consistent with those of previous studies showing that capability is an effective tool for improving undergraduates' innovation outcomes. This reinforces the theoretical foundations for promoting capability development to enhance undergraduates' innovative behaviour in Thailand's educational system. Second, there has been limited discussion of the mediating role of knowledge integration in the relationship between capability and innovative behaviour in the context of education. We inform prior work by supporting knowledge integration theory. The findings of this study empirically examined the mediating effects of knowledge integration on the association between capability and undergraduates' innovative behaviour and confirmed the role of the former.

5-2- Practical Implications

The primary findings of this study have favourable implications for practitioners. Higher education institutions (HEIs) should recognise that five aspects of capability (leadership, technological literacy, interaction, knowledge sharing, and collaboration) can significantly influence undergraduates' innovative behaviour. We highlight the importance of a comprehensive understanding of undergraduates' capability by identifying the dimensions of capability and their effects on their innovative behaviour. Students should be encouraged to cultivate their innovative behaviour in accordance with the five dimensions of capability. Consequently, HEIs can use our findings to rethink educational curriculum development criteria.

Knowledge sharing might boost performance and give possibilities for innovation because it has the greatest impact on innovative behaviour. It should be emphasised as part of the innovation development in universities. Consequently, HEIs should establish strategies to encourage undergraduates to share their knowledge and practises with others by offering appropriate environments, attractive rewards, networking, and reciprocal programmes.

According to Industry 4.0, integration is one of the essential strategic factors for the growth of innovation through collaboration between industry and academics. Educators should prioritise knowledge integration because it may help undergraduates combine, structure, and use different types of capability, such as leadership, technological literacy, interaction, knowledge sharing, and collaboration, each of which represents a multidisciplinary perspective. If HEIs emphasise knowledge integration in the design and implementation of effective educational programmes, this will be a

strong point of the educational system. HEIs may encourage students to grasp knowledge integration and apply it to expand possibilities and generate long-term innovation and competitive strategies. Furthermore, students may integrate new technology and expertise to create innovations in their future workplaces based on the notion of Industry 4.0.

6- Conclusion

The purpose of this study is to investigate the direct effect of capability (leadership, technological literacy, interaction, knowledge sharing, and collaboration) and the indirect effect of knowledge integration's mediating role on undergraduates' innovative behaviour. The findings presented that capability is a significant determinant of innovative behaviour. Additionally, the analysis of five dimensions of capability revealed that knowledge sharing was the strongest predictor of innovative behaviour. The indirect effect also demonstrated that knowledge integration positively mediated the association between capability and innovative behaviour. This finding contributes empirical evidence to the body of knowledge about the capability of undergraduates in developing Asian countries.

Future research in this area should be conducted with the study's limitations in mind. First, the scope was limited to undergraduates enrolling in education faculties at Thailand's independent institutions. It would be intriguing to replicate our results with other academic institutions, vocational schools, or graduate students. Second, data collection in Thailand has been restricted, and the generalisation of results should be analysed with discretion. As a result, various cultural characteristics may influence undergraduates' perceptions of their capability to engage in innovative behaviour. More studies should be done to collect and compare data from other countries. Finally, we solely looked at how capability and knowledge integration affect innovative behaviour. Other results of innovative behaviour should be researched in order to further improve the suggested framework.

7- Declarations

7-1- Author Contributions

S.L. and No.S. conceptualised and participated in study design, coordinated data collection, carried out the initial analyses, drafted the initial manuscript, and read and approved the manuscript. P.T. and Nu.S. participated in the study design, guided the methodology, coordinated, and supervised data collection and analyses, reviewed and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding

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7-4- Acknowledgements

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7-5- Informed Consent

Not applicable.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Questionnaire

No.	Survey Question	Strongly Agree (5)	Agree (4)	Unsure (3)	Disagree (2)	Strongly Disagree (1)
	Capability					
	Leadership					
1	You help others create educational materials by giving advice. (LEAD1)					
2	You encourage group members to share new ideas. (LEAD2)					
3	You instruct your team members on both positive and bad working practises. (LEAD3)					
	Technological literacy					
4	You search about developing educational materials using information technology. (TECH1)					
5	You utilise technology to exchange knowledge. (TECH2)					
6	You apply information technology to produce educational materials. (TECH3)					
	Interaction					
7	You communicate with the team. (INTER1)					
8	You meet people from various groups. (INTER2)					
9	You always exchange knowledge with others. (INTER3)					
	Knowledge Sharing					
10	You share your existing knowledge with others. (KS1)					
11	When you learn new knowledge, you share it with others. (KS2)					
12	You share your experience with others. (KS3)					
	Collaboration					
13	When you disagree with a teammate, you can work together to resolve the conflict. (COLL1)					
14	You have an open discussion with your team. (COLL2)					
15	You appropriately assign tasks to your team. (COLL3)					
	Knowledge Integration					
16	You understand the interrelationship of two or more concepts. (KI1)					
17	Technology can help you be more productive. (KI2)					
18	You combine your ideas with others. (KI3)					
19	You explore the different contexts and apply concepts to each. (KI4)					
20	You link related and unrelated ideas. (KI5)					
	Innovative behaviours					
21	You solve problems by analysing them. (INB1)					
22	You come up with new ideas. (INB2)					
23	You are an expert in information technology. (INB3)					
24	You build a network to assist you generate new ideas. (INB4)					
25	You use the knowledge to make new inventions. (INB5)					
26	Others can utilise your instructional materials. (INB6)					
27	You have an innovative method for developing educational materials. (INB7)					
28	You can evaluate and select educational materials. (INB8)					