

The Needs Assessment for the Development of Mobile Technology Supported Inquiry-Based Collaborative Learning With Gamification to Enhance Digital Information Literacy and Learning Engagement of Undergraduate Students

Chanatat Boonchuvong*, Prakob Koraneekij, and Jintavee Khraisang

Educational Technology and Communication, Faculty of Education, Chulalongkorn University

*Corresponding author: 6184242127@student.chula.ac.th

Received November 19, 2024 ■ Revised December 27, 2024 ■ Accepted December 29, 2024 ■ Published December 31, 2024

Abstract

This study aims 1) to study the need for developing mobile technology to support inquiry-based collaborative learning through gamification that enhances digital information literacy and learning engagement of undergraduate students, and 2) to examine the abilities of students in using devices and mobile technology for inquiry-based collaborative learning. The sample consisted of 426 undergraduates selected using multi-stage sampling. Data were gathered using a questionnaire with a reliability of 0.98. The questionnaire comprised questions on respondents' demographics, learning needs, and students' proficiency in using devices and mobile technology for collaborative learning. Descriptive statistics and the priority need index (PNI-modified) were employed in the analysis. The findings indicated five key needs for boosting students' digital information literacy and learning engagement: 1) mobile technology supporting collaboration, such as brainstorming with peers ($PNI_{modified} = 0.15$), 2) inquiry-based learning through problem- or assignment-based approaches ($PNI_{modified} = 0.19$), 3) gamification using leaderboards to heighten challenge ($PNI_{modified} = 0.14$), 4) digital information literacy, involving systematic management and storage of digital resources ($PNI_{modified} = 0.15$), and 5) learning engagement through regular supplementary materials from instructors ($PNI_{modified} = 0.19$). Regarding students' abilities in using devices and mobile technologies, the findings showed that most learners used technological tools to search for information ($M = 4.41, SD = 0.80$) and relied on Google Chat, Line, and Facebook Messenger as primary platforms for communication and collaboration ($M = 4.31, SD = 0.97$). For content creation, students preferred applications such as Canva, Genially, and Powtoon ($M = 4.16, SD = 0.90$). At the same time, Google Slides, PowerPoint, and Prezi were the main tools used for presenting and publishing work ($M = 4.11, SD = 0.88$).

Keywords: mobile technology, inquiry-based collaborative learning, gamification, digital information literacy, learning engagement

Introduction

Digital technology has played a significant role in communication culture development, knowledge development, business competitiveness, work, and lifestyle, transforming the world into a digital society where communication and access to information are easier and quicker than ever. Education technology, seen initially as a tool to enhance learning and its outcomes, is now considered a tool to develop essential skills for learners as they face more complex issues in the digital world, such as critical thinking skills (Ratchakitchanubeka, 2019). To use digital technology effectively, such as mobile technology-supported collaborative learning in learning enhancement able to implement smartphones or tablets to allow flexibility in learning activities; by using such digital equipment, students can interact with their peers who are not in the class and enable accessibility to learning-support tool students can access new online resources. Students also benefit from sharing their work and knowledge with their classmates (Koh & Kan, 2021). However, online resources are of various qualities, and some inaccurate information is stored among general data; therefore, there is a possibility that false information

is found. In the digital era, online information can be accessed through different channels. To be able to choose high-quality digital data has become a required qualification of learners these days (Weber et al., 2018; Khan, 2020). Digital information literacy and learning engagement are now the skills that must concurrently be developed in living in this digital society's social and working world.

In the higher education setting, digital information literacy is an essential skill that should be emphasized, as it is the skill that leads students to understand the steps and processes needed in gathering data. It will allow them to evaluate the efficiency and credibility of the data while equipping them with skills in acquiring, analyzing, evaluating, and selecting data with the highest potential (Khan, 2020). Learning engagement encourages students to be willing to work for their education. It shows enthusiasm, effort, and tolerance to challenges faced where students can control themselves, be open-minded to put in effort in learning, and tolerate difficulty occurring during the learning process (Jin & Wang, 2019). Inquiry-based collaborative learning is a teaching method that emphasizes higher-order cognitive and scientific

process skills that align with the enhancement of digital information technology and learning engagement (Chen et al., 2022; Gouripeddi & Kannan, 2019). The collaborative learning process motivates students by adding activities that stimulate higher-order thinking skills, such as discussions, criticisms, comments, listening, respecting others' opinions, tolerance, and decision-making. This will help students build the learning process and create knowledge independently (Gouripeddi & Kannan, 2019; Korkman & Metin, 2021; Teig et al., 2018). Additionally, gamification is one of the most effective tools for designing mobile learning and collaborative learning platforms to create engaged learning environments for students, motivating them to learn and participate with others (Sanchez et al., 2020). Several studies have shown that gamification significantly influences learning engagement and learning collaboration (Huang & Hew, 2018; Singh et al., 2021; Tan & Hew, 2016).

As mentioned above, mobile technology that supports collaborative learning can develop digital information literacy and engagement through gamification. Hence, this study will examine the need to organize learning activities to enhance digital information literacy and learning engagement as the initial information to design and develop mobile technology that supports collaborative learning can develop digital information literacy and engagement through gamification from this study's findings.

Objectives

1. To study the need for developing mobile technology to support inquiry-based collaborative learning through gamification that enhances digital information literacy and learning engagement of undergraduate students
2. To study the abilities in using devices and mobile technology for inquiry-based collaborative learning of undergraduate students

Literature Review

Mobile Technology-Supported Collaborative Learning: MTSCCL

Using a smartphone or a tablet in interactive learning activities that require interactions between an instructor and other learners can be done without limitation of time and place, which allows students to work collaboratively through mobile technology. The components of mobile technology-supported collaborative learning are as follows: 1) information technology tools, 2) collaboration and communication tools, 3) creation tools, and 4) evaluation tools (Jaldemark

et al., 2018; Boticki et al., 2020). According to Hinostroza et al. (2024), mobile technology fulfills multiple roles in inquiry-based collaborative learning: 1) guiding the overall inquiry process, 2) illustrating the phenomena under investigation, 3) serving as a channel for accessing learning materials, 4) facilitating data collection, 5) supporting the organization of ideas and information, 6) enabling idea-sharing and communication, and 7) providing a means to receive feedback.

Inquiry-Based Collaborative Learning: IBCL

Designing inquiry-based collaborative learning via mobile technology includes stimulating learners to be curious and creating tasks to present to their group members. At the same time, the instructor keeps encouraging students in the group to find answers from one another so that they can exchange information and ideas, which will eventually lead to group work and a presentation to the whole class. There are 4 steps in inquiry-based collaborative learning: 1) planning, 2) individual inquiry, 3) collaborative inquiry, and 4) group results (Pedaste et al., 2015; Lämsä et al., 2019). Several studies show that in an inquiry-based collaborative learning environment facilitated through mobile technology and featuring a collaborative instructional display that allows students to interact with learning activities, and then findings revealed that inquiry-based collaborative learning positively influences the development of various dimensions of students' information literacy (Chu et al., 2011; Ke, 2010; Zhu et al., 2019).

Gamification

Designing game elements on mobile learning platforms by adopting their mechanics into the learning environment engages students while learning. Gamification influences student motivation, making students feel challenged, and creates an engaged learning environment where students play a part (Kapp, 2012; Rivera & Garden, 2021). To adopt game mechanics and game dynamics, the components consist of 1) goal, 2) rule, 3) time, 4) reward, 5) feedback, 6) level, 7) leaderboard, and 8) score (Tan & Hew, 2016; Rivera & Garden, 2021). Numerous studies show that gamification elements have a significant impact on learning engagement, learning outcomes, learning motivation, and also collaboration between peers (Balalle, 2024; Behl et al., 2022; Buccharone, 2022; Jia et al., 2024).

Digital Information Literacy: DIT

Several overviews of the concept of DIT are the ability of learners to search for, retrieve, and evaluate data from online sources, which consists of information literacy and digital literacy and focuses on the ability

to identify and access desired digital information using appropriate methods. The steps to efficiently determine, analyze, access, and select digital information are 1) define, 2) access, 3) evaluate, 4) manage, and 5) integrate (Encheva et al., 2020; Chen et al., 2022). Furthermore, studies show that Inquiry-based, integrated information literacy instruction enhances both fact memorization and conceptual understanding of digital content and information by leading student reflection, student autonomy, and learning-to-learn skills; inquiry-based learning meaningfully integrates information literacy content for deeper engagement (Chen et al., 2014; Frati, 2020; Gasque, 2016).

Learning engagement

Learning Engagement is crucial for effective learning in both online and traditional educational settings. Research indicates that engaging activities connect course content to real-world issues, integrate previous learning, and encourage higher-order thinking (Buelow et al., 2018). Learning Engagement reflects willingness, dedication, open-mindedness, and challenge acceptance in learning, shown through their enthusiasm, perseverance, and readiness to face

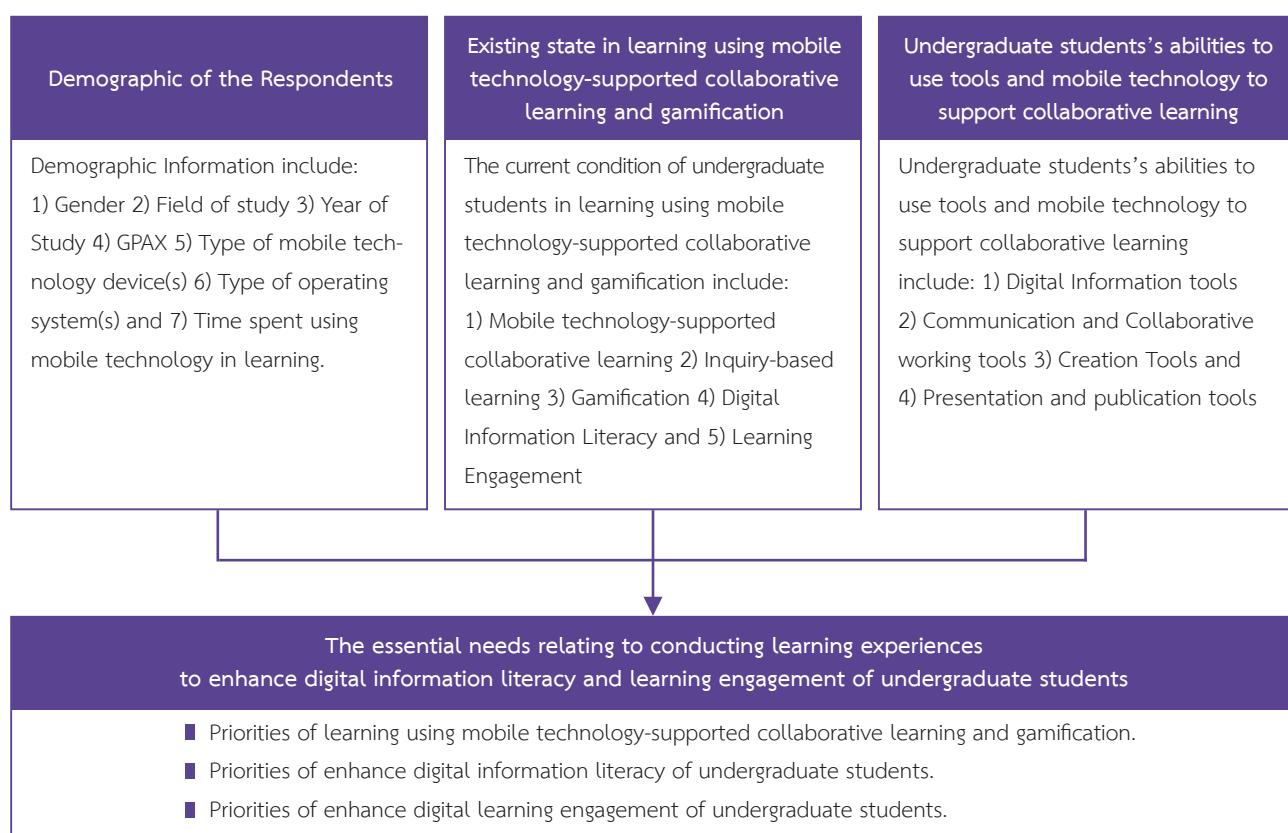
challenges. Learning engagement, which includes engagement with classmates and with learning activities conducted by instructors, can be divided into 3 aspects: 1) behavioral aspect, 2) emotional aspect, and 3) cognitive aspect (Buelow et al., 2018; Lan & Hew, 2020). Digital learning technologies can be leveraged to measure and improve student engagement, offering promising paths for enhancing the learning experience (Organisation for Economic Co-operation and Development [OECD], 2021)

■ Research Methodology

The study employed the survey research method as the primary approach for data collection. The researcher proceeded with the following research methods: 1) to study and analyze the sample demographic, 2) to explore needs in learning using mobile technology-supported collaborative learning and gamification, and 3) to study abilities to use tools and mobile technology to support collaborative learning. The data collection process involved the use of online questionnaires.

Research Framework

Figure 1
Research Framework



Population and Sample

The population of the study of needs for learning organizations to enhance digital information technology and learning engagement is undergraduate students. Overall, undergraduate students in 2024 were 1,862,475 students. Then, the researcher used Yamane's readymade table at the certainty level of 0.5, which resulted in 400 people (Yamane, 1970). The researchers increased the number by 10% to 440 to compensate for the survey's responses.

The sample group is conducted through a multi-stage sampling as follows: 1) randomly select higher education institutions for the three groups of universities: state higher education institutions, state-controlled universities, and private higher education institutions; 2) select faculties in each university selected from step 1 using stratified random sampling according to the three academic fields: 1) science and technology, 2) science and health, and 3) humanities and social sciences. And 3) randomly select undergraduate students in faculties from higher education institutions selected from steps 1 and 2 using simple random sampling.

Research Instruments Development

The researcher developed the items in the questionnaire to consolidate the literature and be more reliable for undergraduate students to understand. Then, the items were compared for theoretical deficiency and redundancy within each construct. The questionnaire consists of 3 parts: 1) personal details of the respondents (8 checklist items), 2) needs in learning using mobile technology-supported collaborative learning and gamification to enhance digital information literacy and learning engagement of undergraduate students (58 items with five rating scale), and 3) abilities to use tools and mobile technology to support collaborative learning (16 items with five rating scale).

Three experts evaluated the questionnaire to assess the questionnaire used in this study for the Index of item-objective congruence (IOC). The result shows that the overall IOC score of the questionnaire was between 0.66-1.00. After that, the survey was tried out on 30 undergraduate students to verify its reliability. The study results were calculated using Cronbach's alpha coefficient, and they were proved to have a reliability score of 0.98 and passed the ethical guidelines for research involving human subjects from Chulalongkorn University (COA No. 061/66).

Data Collection

The researchers sent out a memorandum requesting documents to collect data from the sample group of university students under the Ministry

of Higher Education, Science, Research and Innovation from April 2023 to May 2023. The researcher contacted the subject teachers to request permission to collect data from the research questionnaires by sending the research questionnaires to the subject teachers for consideration. Then, they contacted them about the date/time for data collection in order. After that, the survey's 426 responses were checked to collect data and perform an analysis.

Data Analysis

The analysis of the assessment of undergraduate students' needs in learning was done using the modified priority needs index (PNI_{Modified}), which used Witkin, 1984 5 scales criteria for interpreting the average of PNI_{Modified} values as follows:

- 4.51–5.00 means the actual needs, which is the highest level.
- 3.51–4.50 means the actual needs, which is high.
- 2.51–3.50 means the actual needs, which is moderate.
- 1.51–2.50 means the actual needs, which is low.
- 1.00–1.50 means the actual needs, which is the lowest level.

Then, the descriptive analysis uses the median and standard deviation of the respondents' personal details and their ability to use tools and mobile technology.

Results

In correspondence with the objectives of the study, the findings are divided into three parts, which are: 1) the sample demographic of the respondents, 2) the needs in learning using mobile technology-supported collaborative learning and gamification to enhance digital information literacy and learning engagement of undergraduate students, and 3) abilities to use tools and mobile technology to support collaborative learning.

Part 1 Sample Demographic of the Respondents

The result shows that 237 males (55.63%) and 189 females (44.37%) were among the respondents. Most respondents were students in humanities and social sciences, at 151 students (35.45%), followed by health science students, at 144 students (33.80%). The largest group of respondents were second-year students, at 191 students (44.84%).

Smartphones were the most popular learning device for 348 students (81.69%). Moreover, 321 students (75.76%) used tablets, followed by laptops with 280 students (65.73%). As for the time spent learning using mobile technology, the study shows that most learners, 226 students (53.05%), spent more than 6 hours per

week studying, while around 126 students (29.58%) spent around 4-6 hours weekly, as shown in Table 1.

Table 1
An Analysis of Demographic Information

(n = 426)

Data	Categories	Number	Percentage
Gender	Female	189	44.37
	Male	237	55.63
Field of study	Science Technology	131	30.75
	Science–Health Science	144	33.80
	Humanities and Social Sciences	151	35.45
Year of Study	Year 1	123	28.87
	Year 2	191	44.84
	Year 3	79	18.54
	Year 4	33	7.75
GPAX	0.00–1.00	17	3.99
	1.01–2.00	14	3.29
	2.01–3.00	148	34.74
	3.01–4.00	247	57.98
Which mobile technology device(s) do you use in learning?	Smartphone	348	81.69
	Tablet	327	76.76
	Laptop	280	65.73
Which operating system(s) do you use in learning?	iOS	351	82.39
	Android	156	36.62
	macOS	82	19.25
	Microsoft Windows	252	59.15
	ChromeOS	39	9.15
How long do you use mobile technology in learning?	0–2 hour(s) per week	34	7.98
	2–4 hours per week	40	9.39
	4–6 hours per week	126	29.58
	more than 6 hours per week	226	53.05

Part 2 Needs learning using mobile technology-supported collaborative learning and gamification to enhance digital information literacy and learning engagement of undergraduate students

Regarding the need to learn using mobile technology-supported collaborative learning and gamification to enhance digital information literacy and

learning engagement of undergraduate students, the result of the need for mobile technology-supported collaborative learning shows that the students needed it to allow them to brainstorm and develop their ideas with others the most (PNI_{Modified} = 0.15). As for the need for inquiry-based learning, it was found that once the work or problem was assigned, the students were most

likely to assume solving it before they started working on it ($\text{PNI}_{\text{Modified}} = 0.19$). The result of using gamification reveals that showing a leaderboard in the class, which makes students feel challenged and motivates them to upgrade their level, was the most needed priority ($\text{PNI}_{\text{Modified}} = 0.14$). In terms of digital information literacy needs, it is found that the ability to systematically store and manage digital information that students have found for them to use later was needed the most

($\text{PNI}_{\text{Modified}} = 0.15$). When considering learning engagement, regularly studying the supplementary contents provided by their instructors was the highest-scored item ($\text{PNI}_{\text{Modified}} = 0.19$). Table 2 shows the study's results on the needs in learning using mobile technology-supported collaborative learning and gamification to enhance undergraduate students' digital information literacy and learning engagement, with the three most-needed items for each category.

Table 2
Needs in Learning Using Mobile Technology-Supported Collaborative Learning and Gamification

Topics	Degree of success (D)	Degree	Important (I)	Degree	$\text{PNI}_{\text{Modified}}$	Priorities
Mobile technology-supported collaborative learning						
You can use mobile technology to manage and follow up on teamwork, improving the working process and ensuring it goes as planned.	3.65	High	4.27	High	0.14	2
You can use mobile technology to brainstorm ideas with your teammates.	3.68	High	4.31	High	0.15	1
You can use mobile technology to present your work on the website.	3.78	High	4.34	High	0.13	3
Inquiry-based learning						
You study and review the learning materials before you begin working on an assignment.	3.55	High	4.26	High	0.17	2
Once you receive problems or assignments, you will set assumptions of the solution before starting to work.	3.43	Medium	4.26	High	0.19	1
You outline the work assigned to check your overall idea before creating an original work.	3.60	High	4.28	High	0.16	3
Gamification						
Setting goals and rules in working enables you to work on an assignment more efficiently.	3.78	High	4.35	High	0.13	2
Setting time for each assignment helps you better manage and organize your learning.	3.82	High	4.32	High	0.11	3
Leaderboards in your class make you feel challenged and would like to upgrade your level.	3.41	Medium	3.98	High	0.14	1

Table 2
 (continued)

Topics	Degree of success (D)	Degree	Important (I)	Degree	PNI _{Modified}	Priorities
Digital Information Literacy						
You can systematically manage and store the digital information you have found so you can use it later.	3.67	High	4.30	High	0.15	1
You can interpret and present new knowledge acquired from the digital data you have sought.	3.69	High	4.30	High	0.14	2
You have a system for searching for digital data.	3.77	High	4.35	High	0.13	3
Learning Engagement						
You regularly study the supplementary contents provided by your instructors.	3.34	Medium	4.14	High	0.19	1
You attempt to seek information from other sources apart from the ones prepared by your instructors.	3.41	Medium	4.15	High	0.18	2
When your instructors assign you workpieces, you feel interested and want to do the assignments.	3.46	Medium	4.17	High	0.17	3

Part 3 Abilities to use tools and mobile technology to support collaborative learning

The results show that students could use digital information technology tools to look up data using Google Chrome and Safari the most ($M = 4.41, SD = 0.80$). The ability to edit information using Google documents and Word ($M = 4.08, SD = 0.92$) and manage and store data using various sites and applications ($M = 4.02, SD = 0.86$). Regarding the ability to use communication and collaborative tools, it was found that students can use tools for communication the most ($M = 4.31, SD = 0.97$). The ability to use tools for online meetings ($M = 4.16, SD = 0.80$) and managing and tracking teamwork ($M = 3.13, SD = 1.26$) respectively. The most used

creation tools were Canva, Genially, and PowToon, the creative tools ($M = 4.16, SD = 0.90$). The second and third most used tools were data collection tools, including Google Forms, Survey Monkey, and MS Forms ($M = 3.77, SD = 0.99$), and data processing and analyzing tools such as Google Sheets and Excel ($M = 3.72, SD = 1.04$) respectively. Additionally, the results revealed that students had the highest value in using presentation and publication tools ($M = 4.11, SD = 0.88$). The ability to use tools to publish a video was second ($M = 3.86, SD = 1.11$), and using tools to publicize content, such as SlideShare, was third ($M = 3.46, SD = 1.17$). The details are shown in Table 3.

Table 3
Abilities to use Tools and Mobile Technology to Support Collaborative Learning

Data	Categories	M	SD
Digital Information tools	Tools used for finding data such as Google Chrome, Safari	4.41	0.80
	Tools used for taking notes such as Google Keep, Notes, Good Note, Notability	3.96	1.09

Table 3
(continued)

Data	Categories	M	SD
	Tools used for recording, such as Google Documents, Word	4.08	0.92
	Tools used for managing and storing data, such as Google Drive, Dropbox, and OneDrive	4.02	0.86
Communication and Collaborative working tools	Tools used for online meetings such as Google Meet, Microsoft Teams, Zoom	4.16	0.80
	Tools used for planning such as Google Draw, Miro, Mural	3.12	1.21
	Tools used for managing and tracking teamwork such as Google Tasks, Trello, slack	3.13	1.26
	Tools used for sending messages such as Google Chat, Line, Facebook Messenger	4.31	0.97
Creation Tools	Tools used for storing data, such as Google Forms, Survey Monkey, and MS Forms	3.77	0.99
	Tools used for processing and analyzing data such as Google Sheets, Excel	3.72	1.04
	Tools used for brainstorming and developing ideas such as Padlet, Limniot	3.41	1.06
	Tools used for creating works such as Canva, Genially, PowToon	4.16	0.90
Presentation and publication tools	Tools used for slide presentations such as Google Slides, PowerPoint, Prezi	4.11	0.88
	Tools used for presenting on websites such as Google Sites, WordPress	3.45	1.19
	Tools used for publishing content such as SlideShare	3.46	1.17
	Tools used for publicizing videos such as YouTube, Vimeo	3.86	1.11

Discussion

The study of the respondents' overseas undergraduate students' learning needs toward using mobile technology-supported collaborative learning and gamification to enhance digital information literacy and learning engagement and the ability to use tools and mobile technology to support collaborative learning. First, it found that smartphones were the most popular device among undergraduate students, and the students spent more than 6 hours learning through mobile technology.

Regarding their abilities to use tools and mobile technology to support collaborative learning, the tools the students possessed the highest ability to use were the tools for finding data, such as Google Chrome and Safari. The type of tool for creating and developing work pieces that the students most used was a tool for creating works, including Canva, Genially, and PowToon. Slide presentation tools such as Google Slides, PowerPoint, and Prezi were the most used for presentation and publication tools.

This finding correspondence with the results of the study of the learners' need assessments in using

mobile technology-supported learning, which focused on brainstorming, idea development, and collaborative working, including students' presentations, which was in correlation with Fu and Hwang's study that synthesized the literature relating to mobile technology-supported learning. His study stated that the important thing in creating learners' experiences was to focus on collaborative learning and working and the ability to form knowledge independently (Fu & Hwang, 2018). Additionally, using mobile technology was found to satisfy the needs of inquiry-based learning, which emphasizes works or problems assigned as students would form assumptions before they start working. This is consistent with Wang's study, which talked about the applications of mobile technology in an environment to enhance students' learning through advising on doing activities, accessibility to contents, collaborative data finding, interactions among learners, and giving feedback to learners using mobile technology (Wang et al., 2021). In the gamification part, the finding shows that leaderboards were the most desired game elements, reflecting the insight students need to design competitive and clear goals in the learning environment.

This shows that competition, as a key element of gamification, has been shown to motivate students and improve performance in learning contexts (Jaguš et al., 2018; Liu et al., 2022; Sepehr & Head, 2013). Overall, gamified-enabled learning activities can significantly improve student performance and motivation, particularly those incorporating competition, adaptivity, and narratives (Jaguš et al., 2018; Liu et al., 2022). In addition, mobile technology also helps develop students' learning engagement by motivating them and giving them meaningful and authentic learning. Also, providing various sources of data and communications (Chauhan, 2021; Xu et al., 2023) can develop digital information literacy (Pinto et al., 2020). Inquiry-based collaborative learning can also enhance students' digital information literacy by searching for data and analyzing and evaluating the data before learning through mobile technology (Chen et al., 2022). Using gamification in learning can develop learning engagement and digital information literacy of learners at the university level. (Encheva et al., 2020; Rivera & Garden, 2021).

■ Conclusions

From the study of the essential needs relating to conducting learning experiences to enhance digital information literacy and learning engagement of undergraduate students, it was found that using mobile technology, which supports inquiry-based learning in conjunction with gamification, can satisfy the needs of learners. As for the guidelines to design learning environments, teachers should focus on developing activities that support collaborative learning and working through mobile technology or inquiry-based learning, which allows students to build and integrate their knowledge, creating flexibility in learning and teamwork while also motivating them to learn and develop their digital information literacy via data inquiry for works assigned by teachers. However, students' readiness and ability to use technology need to be considered, and the learning environment should be designed accordingly. Moreover, gamification techniques, whether a badge, level, or leaderboard, can create learning engagement and decrease learning dropout.

■ Declaration of Competing Interest

The authors declare that there is no competing interest in conducting this study.

■ References

Balalle, H. (2024). Exploring student engagement in technology-based education in relation to gamification, online/distance learning, and other factors: A systematic literature review. *Social Sciences & Humanities Open*, 9, Article 100870. <https://doi.org/10.1016/j.ssaho.2024.100870>

Behl, A., Jayawardena, N., Pereira, V., Islam, N., Giudice, M. D., & Choudrie, J. (2022). Gamification and e-learning for young learners: A systematic literature review, bibliometric analysis, and future research agenda. *Technological Forecasting and Social Change*, 176, Article. 121445. <https://doi.org/10.1016/j.techfore.2021.121445>

Boticki, I., Uzelac, N., Dlab, M. H., & Hoić-Božić, N. (2020). Making synchronous CSCL work: a widget-based learning system with group work support. *Educational Media International*, 57(3), 187-207. <https://doi.org/10.1080/09523987.2020.1824420>

Buccharone, A. (2022). Gamification and virtual reality for digital twin learning and training: architecture and challenges. *Virtual Reality & Intelligent Hardware*, 4(6), 471-486. <https://doi.org/10.1016/j.vrih.2022.08.001>

Buelow, J. R., Barry, T., & Rich, L. E. (2018). Supporting learning engagement with online students. *Online Learning*, 22(4), 313-340. <https://doi.org/10.24059/olj.v22i4.1384>

Chauhan, S. P. (2021). Technology-supported classroom for collaborative learning. *Interdisciplinary Research in Education*, 6(2), 99-106. <https://doi.org/https://doi.org/10.3126/ire.v6i2.43542>

Chen, C. -M., Li, M. -C., & Chen, Y. -T. (2022). The effects of web-based inquiry learning mode with the support of collaborative digital reading annotation system on information literacy instruction. *Computers & Education*, 179, Article 104428. <https://doi.org/10.1016/j.compedu.2021.104428>

Chen, L. C., Yan, R. D., & Huang, T. W. (2014). The effects of inquiry-based integrated information literacy instruction: Four-year trends. *Journal of Educational Media and Library Sciences*, 51(4), 561-595. <https://doi.org/10.6120/JoEMLS.2014.514.0629.RS.CM>

Chu, S. K. W., Tse, S. K., & Chow, K. (2011). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library & Information Science Research*, 33(2), 132-143. <https://doi.org/10.1016/j.lisr.2010.07.017>

Encheva, M., Tammaro, A. M., & Kumanova, A. (2020). Games to improve students' information literacy skills. *The International Information & Library Review*, 52(2), 130-138. <https://doi.org/10.1080/10572317.2020.1746024>

Frati, F. Y. E. (2020). Using an inquiry-based learning approach to support engagement with information and scholarship in health care education. *Education for Information*, 36(1), 59-67. <https://doi.org/10.3233/EFI-190334>

Fu, Q. -K., & Hwang, G. -J. (2018). Trends in mobile technology-supported collaborative learning: A systematic review of journal publications from 2007 to 2016. *Computers & Education*, 119, 129-143. <https://doi.org/10.1016/j.compedu.2018.01.004>

Gasque, K. C. G. D. (2016). Information literacy for inquiry-based learning. *Transinformacao*, 28(3), 253-262. <https://doi.org/10.1590/2318-08892016000300001>

Gouripeddi, S. P., & Kannan, V. ((2019, Dec 9-11)). *Implementing inquiry based collaborative learning in solid state physics course* [Conference presentation]. IEEE Tenth International Conference on Technology for Education (T4E), Goa, India. <https://doi.org/10.1109/T4E.2019.00059>

Hinostroza, J. E., Armstrong-Gallegos, S., & Villafaena, M. (2024). Roles of digital technologies in the implementation of inquiry-based learning (IBL): A systematic literature review. *Social Sciences & Humanities Open*, 9, Article 100874. <https://doi.org/10.1016/j.ssaho.2024.100874>

Huang, B., & Hew, K. F. (2018). Implementing a theory-driven gamification model in higher education flipped courses: Effects on out-of-class activity completion and quality of artifacts. *Computers & Education*, 125, 254-272. <https://doi.org/10.1016/j.compedu.2018.06.018>

Jaguš, T., Botički, I., & So, H. -J. (2018). Examining competitive, collaborative and adaptive gamification in young learners' math learning. *Computers & Education*, 125, 444-457. <https://doi.org/10.1016/j.compedu.2018.06.022>

Jaldemark, J., Hrastinski, S., Olofsson, A. D., & Öberg, L. -M. (2018). Editorial introduction: Collaborative learning enhanced by mobile technologies. *British Journal of Educational Technology*, 49(2), 201-206. <https://doi.org/10.1111/bjet.12596>

Jia, F., Bao, X., & Yu, J. (2024). Gamification on digital platform: A meta-analysis of affordance on behavior from value perspective. *Electronic Commerce Research and Applications*, 68, Article 101465. <https://doi.org/10.1016/j.elrap.2024.101465>

Jin, G., & Wang, Y. (2019). The influence of gratitude on learning engagement among adolescents: The multiple mediating effects of teachers' emotional support and students' basic psychological needs. *Journal of adolescence*, 77, 21-31. <https://doi.org/10.1016/j.adolescence.2019.09.006>

Kapp, K. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. John Wiley & Sons.

Ke, I. (2010). Teaching information literacy for inquiry-based learning. *The Journal of Academic Librarianship*, 36(3), 264. <https://doi.org/10.1016/j.acalib.2010.03.014>

Khan, A. (2020). Digital information literacy skills of Pakistani librarians: Exploring supply-demand mismatches, adoption strategies and acquisition barriers. *Digital Library Perspectives*, 36(2), 167-189. <https://doi.org/10.1108/DLP-01-2020-0003>

Koh, J. H. L., & Kan, R. Y. P. (2021). Students' use of learning management systems and desired e-learning experiences: are they ready for next generation digital learning environments? *Higher Education Research & Development*, 40(5), 995-1010. <https://doi.org/10.1080/07294360.2020.1799949>

Korkman, N., & Metin, M. (2021). The effect of inquiry-based collaborative learning and inquiry-based online collaborative learning on success and permanent learning of students. *Journal of Science Learning*, 4(2), 151-159. <https://eric.ed.gov/?id=EJ1292922>

Lämsä, J., Hämäläinen, R., Koskinen, P., Viiri, J., & Mannonen, J. (2019). The potential of temporal analysis: Combining log data and lag sequential analysis to investigate temporal differences between scaffolded and non-scaffolded group inquiry-based learning processes. *Computers & Education*, 143, Article 103674. <https://doi.org/10.1016/j.compedu.2019.103674>

Lan, M., & Hew, K. F. (2020). Examining learning engagement in MOOCs: A self-determination theoretical perspective using mixed method. *International Journal of Educational Technology in Higher Education*, 17, Article 7. <https://doi.org/10.1186/s41239-020-0179-5>

Liu, Y.-J., Zhou, Y.-G., Li, Q.-L., & Ye, X.-D. (2022). Impact study of the learning effects and motivation of competitive modes in gamified learning. *Sustainability (Switzerland)*, 14(11), Article 6626. <https://www.mdpi.com/2071-1050/14/11/6626>

OECD. (2021). *OECD Digital education outlook 2021: Pushing the frontiers with artificial intelligence, blockchain and robots*. OECD Publishing. <https://doi.org/10.1787/589b283f-en>

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., Manoli, C. C., Zacharia Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47-61. <https://doi.org/10.1016/j.edurev.2015.02.003>

Pinto, M., Fernández-Pascual, R., Caballero-Mariscal, D., & Sales, D. (2020). Information literacy trends in higher education (2006–2019): Visualizing the emerging field of mobile information literacy. *Scientometrics*, 124(2), 1479-1510. <https://doi.org/10.1007/s11192-020-03523-4>

Ratchakitchanubeksa. (2019). Prakāsok ra sūang suksāthikān rūang mātrathān khunnawuthi radap parināy trī sākhā kharusāt læ sākhā suksā sāt (laksūt sī pī) Phō.Sō. 2562 [Announcement of the Ministry of Education on bachelor's degree qualification standards in education and educational studies (4 year program) 2019]. Ratchakitcha. <https://ratchakitcha.soc.go.th/documents/17073476.pdf>

Rivera, E. S., & Garden, C. L. P. (2021). Gamification for student Engagement: a framework. *Journal of Further and Higher Education*, 45(7), 999-1012. <https://doi.org/10.1080/0309877X.2021.1875201>

Sanchez, D. R., Langer, M., & Kaur, R. (2020). Gamification in the classroom: Examining the impact of gamified quizzes on student learning. *Computers & Education*, 144. Article 103666. <https://doi.org/10.1016/j.compedu.2019.103666>

Sepehr, S., & Head, M. (2013). Competition as an element of gamification for learning: An exploratory longitudinal investigation. In L. E. Nacke, P. K. Harrigan, & P. N. Randall (Eds.), *Gamification '13: Gameful Design, Research, and Applications* (pp. 2-9). Association for Computing Machinery. <https://doi.org/10.1145/2583008.2583009>

Singh, A., Sharma, S., & Paliwal, M. (2021). Adoption intention and effectiveness of digital collaboration platforms for online learning: the Indian students' perspective. *Interactive Technology and Smart Education*, 18(4), 493-514. <https://doi.org/10.1108/ITSE-05-2020-0070>

Tan, M., & Hew, K. F. (2016). Incorporating meaningful gamification in a blended learning research methods class: Examining student learning, engagement, and affective outcomes. *Australian Journal of Educational Technology*, 32(5). Article 2232. <https://doi.org/10.14742/ajet.2232>

Teig, N., Scherer, R., & Nilsen, T. (2018). More isn't always better: The curvilinear relationship between inquiry-based teaching and student achievement in science. *Learning and Instruction*, 56, 20-29. <https://doi.org/10.1016/j.learninstruc.2018.02.006>

Wang, C., OuYang, J., & Wu, F. (2021). Subgroups of assessor and assessee: The relationship between students' peer assessment roles and perceptions of MSCL in science education. *Journal of Science Education and Technology*, 30, 816-828. <https://doi.org/10.1007/s10956-021-09922-3>

Weber, H., Hillmert, S., & Rott, K. J. (2018). Can digital information literacy among undergraduates be improved? Evidence from an experimental study. *Teaching in Higher Education*, 23(8), 909-926. <https://doi.org/10.1080/13562517.2018.1449740>

Witkin, B. R. (1984). *Assessing needs in educational and social programs*. Jossey-Bass Publishers.

Xu, Q., Sun, D., & Zhan, Y. (2023). Embedding teacher scaffolding in a mobile technology supported collaborative learning environment in English reading class: students' learning outcomes, engagement, and attitudes. *International Journal of Mobile Learning and Organisation*, 17(1/2), 280-302. <https://doi.org/10.1504/ijmlo.2023.128340>

Yamane, T. (1970). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.

Zhu, G., Xing, W., & Popov, V. (2019). Uncovering the sequential patterns in transformative and non-transformative discourse during collaborative inquiry learning. *The Internet and Higher Education*, 41, 51-61. <https://doi.org/10.1016/j.iheduc.2019.02.001>