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An innovation-based virtual flipped learning system in a ubiquitous learning environment the 21st century skills of higher education learners

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ABSTRACT: This research aims to develop an innovation-based virtual flipped learning system in a ubiquitous learning environment to enhance twenty-first-century learning skills in information, media, and technology of learners in higher education. The study employed a design-based research method to study the needs and user experiences of students and teachers. The system consists of three components: (1) a flipped classroom, (2) a virtual learning system and (3) a ubiquitous learning environment and involved five steps: (1) preparing learners, (2) setting learning objectives, (3) self-studying online content, (4) meeting with teachers and classmates to expand knowledge and (5) assessing results. The participants were 97 undergraduate students. This study found that students had twenty-first-century learning skills in information, media, and technology literacies after studying were significantly higher at the highest level in every skill. The average scores of the test before the study, during the study and after the study had heightened attitude levels and information, media, and technology literacies with statistical significance at the .05 level. The results of the test after the study had the highest average scores, followed by those from and before the study. This indicates that the developed innovation can improve the overall attitude and information, media, and technology literacies of learners.

Keywords: Virtual learning, Flipped learning, Ubiquitous learning environment, 21st century skills, Higher education

1. Introduction

Essential skills for working in the twenty-first century include critical thinking, leadership, and those media and technology skills that will help workers adapt to global changes, especially in the immediate context of the COVID-19 pandemic (World Economic Forum, 2020). In addition, the Education 2030 Framework for Action discusses the use of information technology in teaching and learning that, in turn, promotes lifelong learning. It focuses on flexibility in learning to create opportunities for informal learning, enhance classroom learning and support skills acquisition in media, information and technology (UNESCO, 2015). This is in line with Thailand's current strategies to move the country toward Thailand 4.0, focusing on driving the economy through innovation. (The Secretariat of the Prime Minister, 2017) Therefore, the development of education must be in line with the provision of manpower that meets the needs of the country. To develop highly qualified learners with a high standard according to the objectives, educational technology has played an important role in driving the quality of learning to meet the needs of the global society including Thailand (National Education Act, 2010).

This is consistent with the policy statement of Thailand's Ministry of Information and Communication Technology (2014), which proposed policies related to the application of information and communication technology to enhance lifelong learning (e.g., smart learning). The report promoted innovation in teaching and learning by applying information technology to reform teaching styles and processes for learning at all levels. Mobile electronic devices have been used to enable students to learn anywhere and anytime. In addition, according to the Global Digital Use Survey in 2021, Thailand has 97.7% of internet usage through mobile devices and a 7.4 % increase in the usage trend (Kemp, 2021).

Learners in the digital age expect more interactive and challenging technology than that found in traditional classroom teaching settings that mostly offers lectures and discussions. Therefore, teachers should recognize the value of adding new, alternative learning methods for organizing learning, which means that learners will learn effectively. The teachers should focus on providing learners with lifelong learning skills and the learning skills necessary for the twenty-first century, including thinking skills and meaningful learning through information technology. This will lead to the ultimate goal of education, which is to create innovations, resulting in learners

becoming valuable citizens in a global society (Haryani et al., 2021; Khlaisang & Mingsiritham, 2016; Portuguez Castro & Gómez Zermeño, 2020; Yusuf et al., 2021).

To address the above issues concerning information, media, and technology literacies literacy in the 21st century learning, life-long learning with all-time access to learning resources, and responses to the demands of the ever changing global society, especially in terms of the use of technology in learning as a result of the COVID-19 pandemic, a virtual flipped learning system is employed. The system allows students and teachers to interact and learn together. It also emphasizes the learning process on a conditional basis and in real-world contexts through various mobile devices that students already have, based on the Bring Your Own Devices concept. The design is based on the ubiquitous learning environment (ULE). Learning can happen anywhere and anytime, allowing students to learn by themselves. However, teaching experience and age can affect undergraduate students' professional development and digital competence. Therefore, regarding education policy, enhanced digital competence would enable students to act in to act as empowered citizens concerning responsible technology use (Inamorato dos Santos et al., 2023).

The concept focuses on knowledge-building so that students can learn meaningfully. It allows learners to access information as needed. Students can communicate and interact with teachers and classmates to exchange information and discuss the learning process and content (Feng & Hu, 2020; Khlaisang, 2018; Mohaimen-Bin-Noor et al., 2021; Pishtari et al., 2020; Suartama et al., 2021). Flipped classrooms appear to contribute to cognitive and social constructivism by exchanging opinions among learners (Dalbani et al., 2022).

In addition, the virtual flipped learning system answers the needs of twenty-first-century learning skills for information, media, and information and communication literacy. It expands learning time and develops digital literacy without limitations of time and place. Therefore, it can be seen that the application of technology that students are already familiar with, including the use of the learning system, the use of mobile devices combined with flipped learning and virtual learning, can create a teaching innovation that meets the needs of digital literacy of learners in the twenty-first century. This aligns with the study by Cekić-Jovanović et al. (2019) on the impacts of the flipped classroom on improving the future competencies of undergraduate students in the Faculty of Education. It was found that the flipped classroom positive impacted learners' socio-emotional skills, ICT literacy, and learning to learn. In addition, Latorre-Cosculluel et al. (2021) suggested that flipped classrooms could enhance learners' future skills, including collaboration, communication, and citizenship.

However, some studies have addressed the limitations of virtual flipped learning, including the issue of students' lack of preparation (Shyr & Chen, 2017) and a lack of interest in the media presented (Pugsee, 2017). Mobile devices were used to address these problems. This supports the ULE that reduces the limitations of the virtual learning environment in terms of expensive and hard-to-access virtual reality technologies (Zhang et al., 2018). The devices can support interoperability between physical and virtual environments and promote learning in an online and real-time environment made up of different types of learning and support collaborative learning (Virtanen et al., 2016).

This study aims to develop an innovation-based virtual flipped learning system in the ULE to enhance twenty-first-century learning skills in information, media, and technology of higher education learners. This research design is based on the cognitive and social constructivism learning theory through self-directed learning, knowledge sharing, and constructionism to enhance learners' ICT literacy and soft skills. In addition to developing learners' information technology literacy, it promotes personalized learning in response to personalized individual learning and physical limitations using a chatbot. The study followed the design-based research (DBR) model based on the theory of design principles from the user experience (UX) and learning theories. It studied the results of the use of learners' innovation to obtain guidelines for further application. For example, the study of Julie et al. (2020) used design-based research to design learning activities and the use of technology by exploring the opinions of students, teachers, activity designers, and experts in media and computer science in order to enhance learners' digital literacy. Another study by Sekarningsih et al. (2021) adopted design-based research of which its elements including design, development, evaluation, and revision, in designing web-based learning to support teaching and learning management during the COVID-19 pandemic

2. Literature review

2.1. Educational 2030 framework

The Sustainable development is the goal of UN Education in 2030, of which the emphasize is on high quality and equitable education and life-long learning. For this study, the key objectives are as follows: (1) an increasing number of learners possess the skills required in the workplace and labor market as well as entrepreneurship, (2) people in general have the opportunity to develop different types of literacies, and (3) every learner has the knowledge and skills required for sustainable self and peer development and for becoming a competent global citizen (UNESCO, 2015).

2.2. Flipped classroom

A flipped classroom is a learning management process that uses technology to facilitate learning. This emphasizes the use of video streaming to deliver learning content before teaching and learning activities. Classroom activities aim to expand knowledge through the use of various technologies suitable for interactive learning, and the flipped classroom employs various mobile devices to allow students to create projects, assignments, and innovations (Beason-Abmayr et al., 2021; Kang & Kim, 2021; Madariaga et al., 2021; Velde et al., 2021). Studies showed that flipped classrooms helped individuals to learn the contents at their own pace, promoted learning through technology both inside and outside the classroom and enhanced the 21st-century skills, high-order thinking skills, and soft skills (Khlaisang, 2018; Khlaisang et al., 2021; Ferguson, 2023). In addition, flipped learning combines forms of synchronous and asynchronous learning that foster constructivist learning (Fuchs, 2021; Noguera et al., 2022). Steps in organizing flipped classroom learning activities are : (1) preparing learners and the environment, (2) setting learning strategies and objectives, (3) selecting the appropriate technology to transfer the content to enable learners to develop conceptualization and learning, (4) organizing activities to motivate learners to advance their learning at a high level and to ensure that learners have access to the technology required for learning, and (5) using various assessment methods (Bergmann & Sams, 2012; Hamdan et al., 2013; Khlaisang, 2018; Wang, 2021).

2.3. Virtual learning system

The virtual learning system is the structure of teaching through an IT system including computers, laptops, mobile devices, and applications in the same manner as found in normal teaching. It has the features of classroom participation, learning content, tests, homework, grading, assessments, and other external resources to facilitate learning. Students and teachers can communicate and discuss issues at any time. Learners can study content anytime, anywhere, with various devices. There are interactive and collaborative modes of teaching. It is regarded as the management of distance education in a borderless world where there are no restrictions on time, place, or access to equipment (Martín et al., 2021; Phelps & Vlachopoulos, 2020; Rashid et al., 2021; Zhao et al., 2010). Rosmansyah and Ashaury (2018) used a 3D virtual environment to develop learners' 21st century learning skills. It was found that the virtual environment helped improve learners' self-directed learning skills, ICT literacy, problem-solving skills, and thinking skills. The key components of an effective learning system are: (1) addressing content management and presentation, (2) providing teaching materials and learning activities, (3) employing both synchronous and asynchronous communication, (4) interaction, (5) a learner tracking system, and (6) facilitating tools for learners (Ducange et al., 2017; Weller, 2007).

2.4. Ubiquitous Learning Environment (ULE)

The ULE is a learning environment where learners can learn anywhere and anytime via wireless devices and learners can learn and work together. An assessment is conducted according to the actual conditions. Instant feedback is provided to enable learners to improve their learning (Ahmed et al., 2017; Liu et al., 2021; Qun, 2021). The important components of ULE are : (1) allowing learners to study anytime and anywhere, (2) an emphasis on self-studying and knowledge-building to enable learners to learn meaningfully, (3) using computer systems in learning management and data management, (4) using a wireless network connection, (5) allowing learners to access information as needed, (6) enabling communication and interaction between teachers and learners to exchange information and discuss issues, and (7) taking into account the learning environment, both the real environment and virtual environment, which can be adapted from the use of technology to detect the learner's position, as well as to provide sufficient information for learners. Vladova et al. (2019) used a chatbot

as an avatar in the online learning of individual learners to assist leaners and provide them with flexibility in learning. Similarly, Neumann et al. (2021) used a chatbot as a tool to check the learners' learning process in order to promote self-directed learning among university students. Therefore, a chatbot was used in this study as a tool to answer students' problems. Its prominent feature is flexible communication. It facilitates communication anywhere, anytime through a variety of communication channels (Mobility), interaction (Interactivity), and meeting individual learning needs (Personalisation). It provides convenient communication to learners and responds to learning. The chatbot used in this study is in the form of a retrieval-based model that was developed by setting conditions and having a set of instructions and pre-defined dialogues to communicate with learners (Cárdenas-Robledo & Peña-Ayala, 2018; Chin & Chen, 2013; Huang & Chiu, 2015).

2.5. Twenty-first-century learning skills in information, media, and technology

OECD (2008) stated that the 21st century learning skills were important to the global economy. The three main skills were (1) life and career skills, (2) learning and innovation skills, and (3) information, media, and technology skills. This research applies those twenty-first-century learning skills that comprise three key fundamental components: (1) information literacy, (2) media literacy, and (3) ICT literacy. Other soft skills, such as communication skills, collaboration skills, and attitude, were also used to achieve learning. According to Khlaisang and Koraneekij (2019), information literacy referred to the level of knowledge and understanding of the appropriate and effective use of information. Media literacy referred to the ability to access, analyse, evaluate, and create information in different contexts as well as realize the impacts of media exposure and the ability to select useful information and suppress inappropriate information. ICT literacy referred to the ability to use digital technology, communication tools, and/or networks to access, manage, integrate, evaluation, and create a digital media in a knowledge society.

3. Methodology

3.1. Participants

The participants in this study were 97 higher education students, including 63 females, accounting for 64.9% and 34 males, accounting for 35.1% of the cohort. Simple random sampling was used to recruit samples representing the population of undergraduate students in the Faculty of Education with similar ability levels. They were classified into two groups according to their fields of study, including general disciplines and computer-related disciplines. As this was a trial of educational innovation, the emphasis was placed on one experimental group, and no control group was used. The largest group of participants (34 students) were 21 years old, accounting for 35.1%, followed by 20 years old (27 students, accounting for 27.8%) and 22 years old (24 students, accounting for 24.7%). The 58 students who studied general disciplines accounted for 59.8% and 39 students who studied computer and educational technology, accounting for 40.2%. Most participants (64 students) were in their third and fourth year of study, accounting for 66.0%, and 33 students were in their first and second year of study, accounting for 34.0%.

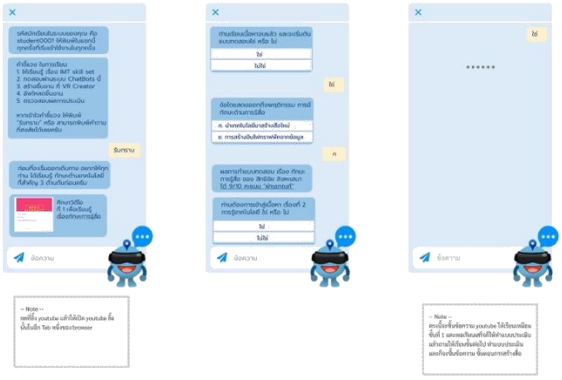
In terms of computer ownership, almost all students (96 students) had their own computer, accounting for 99.0%. Most students (66 students) had used technology to develop a virtual learning environment, accounting for 68.0%. Most of them used the Thinglink program for virtual learning and 31 students, 32.0% had never used virtual learning. In addition, when considering the chatbot experience, 85 students, 87.6%, used the Line application, followed by Facebook. Similarly, 81 students, 83.5%, had used the flipped classroom. Students used video streaming/on-demand applications most, followed by Massive Open Online Courses (MOOCs) and e-learning. Most students (44 students) self-reported that they have had a high level of confidence, accounting for 45.4%, followed by a moderate level of confidence, 34 students, 35.1%, and a low level of confidence 19 students, 19.6%.

3.2. Experimental design

This study is an exercise in the research and development of learning innovations. The study used the DBR approach to collect information about the UX to act as data in the design along with design principles and learning theories. This research employed multimedia principles (Clark & Mayer, 2011) such as the contiguity principle, personalization, voice and image principle. It applied a chatbot as a learning assistant for learners (Figure 1). learning was conducted through video media. The content was divided into presentations following

the segmenting and pertaining principles. In addition, the learning theory of cognitive constructivism and social constructivism have been applied for activity design that allowed learners to reflect after learning.

Figure 1. Use of chatbot



3.3. Research innovation

This design-based research resulted in an innovation called VR Journey, a platform where learners independently learned about information literacy, media literacy, and technological literacy using a chatbot (Figure 1). This flipped learning was based on cognitive constructivism. Subsequently, the learners undertook their works in the VR Creator (Figure 2) with an emphasis on enabling learners to apply their knowledge through creations, and they later exchanged ideas with their peers in the VR Gallery (Figure 3). This flipped learning was based on social constructivism. In this process, learners were able to develop their soft skills (collaboration and communication).

VR Journey was a web application designed and developed by the researchers. Learners entered the learning system at https://vrjourney.club/. While participating in the activities, learners learned the content independently with the help of a chatbot on Facebook Messenger, which was available at all times. Learners also received feedback on the completed activities from the teacher (Figure 1). Before the course began, learners had to take a pre-test to assess their knowledge. Learners then learned the content about twenty-first-century learning skills in information, media, and technology on YouTube. After each topic was delivered, learners had to use the knowledge obtained from the course to create a piece of media in the form of virtual reality using Thinglink on VR Creator (Figure 2). Learners could add hashtags, like others' work, and share their work on VR Gallery (Figure 3).

Figure 2. VR creator

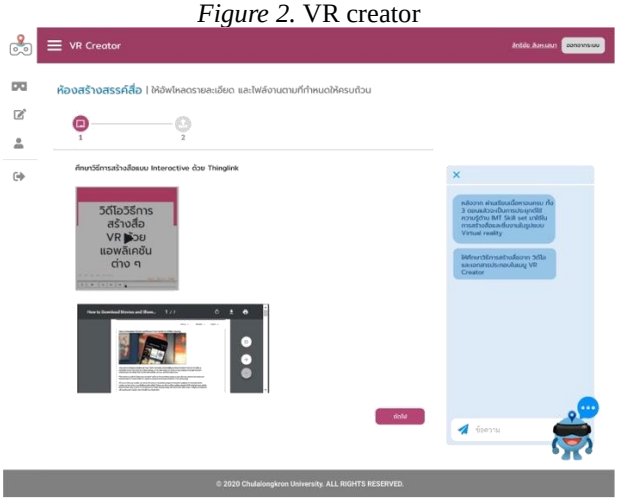
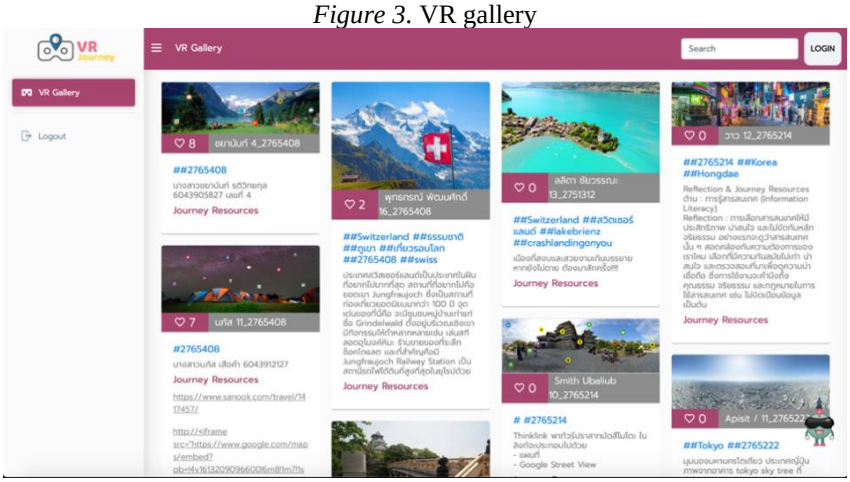


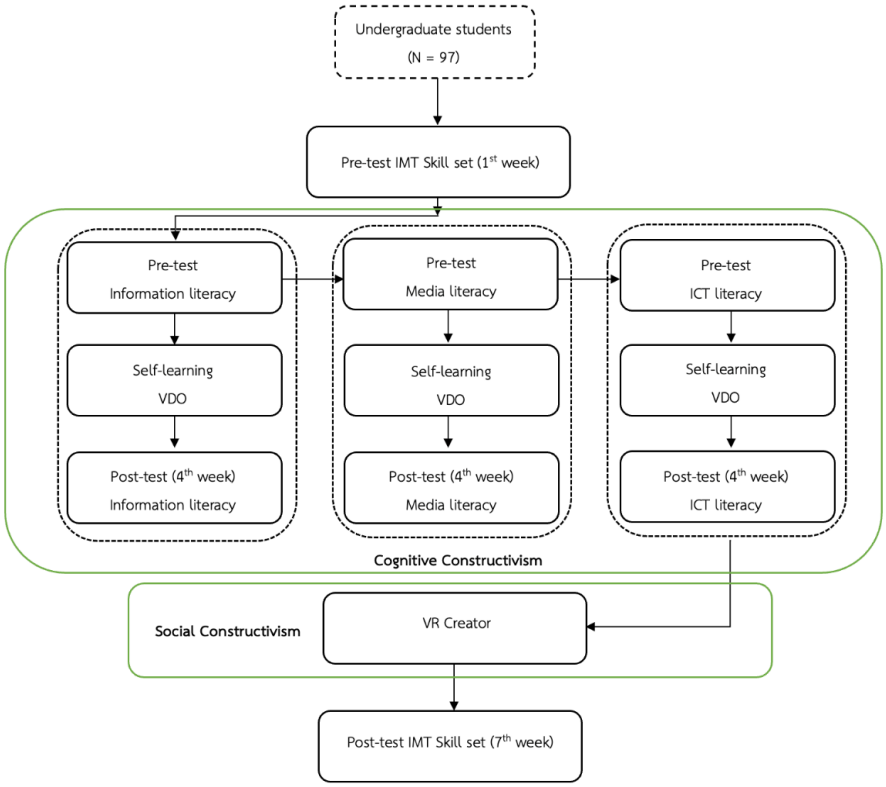
Figure 3. VR gallery



3.4. Experimental procedure

Figure 4 shows the steps in the experiment. Students registered via a chatbot at https://vrjourney.club and took a pre-test. The content was presented sequentially starting from information literacy, media literacy, to technological literacy. When the students had finished studying, they reflected on what they had learned and applied that knowledge to create an authentic project using the VR Creator with assistance from a chatbot and presented their work in the VR Gallery.

Figure 4. Diagram of the experimental design



3.5. Instrument

3.5.1. Model of an innovation-based virtual flipped learning system

A model of an innovation-based virtual flipped learning system in a ULE to enhance twenty-first-century learning skills in information, media and technology of higher education learners has three components: (1) the

Flipped Classroom, (2) a virtual learning environment and (3) an ULE and involved five steps: (1) preparing learners, (2) setting learning objectives, (3) self-studying online content, (4) meeting with teachers and classmates to expand knowledge, and (5) assessing the actual conditions, as shown in Figure 5 and Table 2. The evaluation results regarding innovation types and descriptions were verified by nine experts, and the learning model was found to be feasible (M = 4.78, SD = 0.42).

In this study, exploratory factor analysis was conducted to assess fundamental components of learning innovation design and development. The analysis results revealed four components (Eigen value = 1.681, Cumulative = 71.321), namely (1) the characteristics of the virtual flipped classroom, (2) the characteristics of ubiquitous learning environment, (3) the learning management to promote twenty-first-century learning skills in information, media, and technology, and (4) the learner roles, as shown in Table 1. There were also learning steps in line with these components to improve twenty-first-century learning skills in information, media, and technology of undergraduate students, as shown in Table 2.

Figure 5. Model of an innovation-based virtual flipped learning system

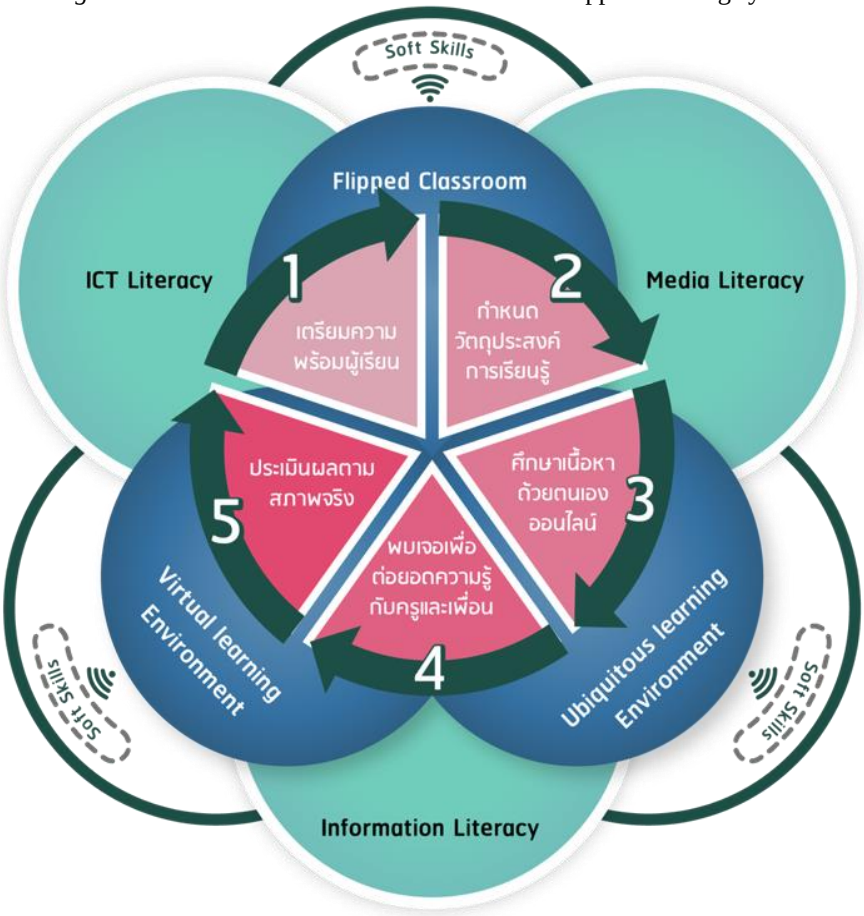


Table 1. Factors and meaning

Factors	Meaning
1. Characteristics of the virtual flipped classroom	The virtual flipped classroom refers to the instruction delivered online through a computer or an online device. It is similar to a traditional classroom in that there are attendance, structured content, testing, knowledge accumulation, and assessment and evaluation. It allows flexibility in learning as learners can learn the content anywhere, anytime, while interacting with one another. With the assistance of a chatbot, learners can learn and work collaboratively.
2. Characteristics of ubiquitous learning environment	A ubiquitous learning environment is the learning context that considers learners' learning environment. Learners can learn anywhere, anytime, as it highlights self-directed learning, constructivism, and meaningful learning. In this study, a chatbot is used as a tool to facilitate these purposes. The dominant features of ubiquitous learning are its communication flexibility, communication channel mobility, interaction, and personalization. It allows learners to communicate conveniently and learn effectively.

3. Learning management to promote twenty-first-century learning skills in information, media, and technology	This learning management uses technology to facilitate learning-based video streaming for delivering content about twenty-first-century learning skills in information, media, and technology. Learners later use the knowledge obtained from the course and technology to create a piece of media in the form of virtual reality.
4. Learner roles	Learner roles include the ability to access learning resources, the ability to use technology for learning, and the ability to manage time for learning.

Table 2. Learning steps

Steps	Details
1. Preparing learners (Factor1 and 2)	At this stage, students log in to the system by using the code received from teachers and learn about course details through Bot Greeting.
2. Setting learning objectives (Factor 1)	At this stage, students will be given instructions on how to execute activities the chatbot.
3. Self-studying online content (Factor 3 and 4)	Students acquire twenty-first-century learning skills in information, media, and technology through video streaming, facilitated by chatbots. When students finish studying the video, they will take a test via a chatbot to assess their learning. If the students do not pass the test, the system will let them study again and take the test again. If students pass the test, the system will show the next item of content to study.
4. Meeting with teachers and classmates to expand knowledge (Factor 3 and 4)	Once the students have completed learning modules, the chatbot will direct them to the VR Creator room. Students will apply their information, media, and technology skills to create virtual reality media and projects. Students learn how to create interactive media via Thinglink and choose the tools to create work according to their interests.
5. Assessing the results. (Factor 4)	Students present their work in the VR Gallery. Viewers can wear a device to view or choose a normal view. In addition, on the student's profile page, they can check their learning progress, including scores and feedback from teachers.

3.5.2 Data collection

The tools used to obtain quantitative data in this study were (1) a questionnaire on learning skills and attitudes consisting of 10 situational questions with a 5-point rating scale; (2) assessment forms for information literacy, media literacy, and technology literacy categorized by learning topics with a 5-level rating scale; and (3) a rubric for evaluating students' work. Before being used for data collection, the tools were validated by five experts in educational technology and assessment and evaluation. In the internal consistency analysis, Cronbach's alpha coefficient was .887.

The qualitative data were collected through observation during the working period using scoring rubrics for 21st century skills in information, media, and technology literacy, and soft skills, such as collaboration and communication, in addition to interviews of learners.

3.5.3 Data analysis

Two-way analysis by MANCOVA repeated measurement was conducted to compare the differences in twenty-first-century learning skills in information, media and technology literacy before, during and after the study by self-learning in a ULE and using smart, wearable technology devices, classified by the field of study and the year of study, with experience in using computers as an extraneous variable. Performance assessment was conducted by using rubrics scoring. Information, media, and ICT literacy before and after the study were assessed by using dependent *t*-test analysis.

4. Result

4.1. Analysis results of twenty-first-century learning skills in information, media and technology

Table 3 presents the results of the analysis of twenty-first-century learning skills in information, media and technology by comparing the results before, during and after learning. During and after learning, it was found

that learners have all twenty-first-century learning skills in information, media, and technology at the highest level. It can be seen that the innovation-based virtual flipped learning system in a ULE helped students to develop skills in information, media, and technology.

When classified by the field of study and year of study, with experience in using computers as an extraneous variable, it was found that the variables of the field of study and year of study did not affect the attitude and information, media, and technology literacy with statistical significance at the .05 level (F = 1.898, 1.179; *sig* = .153, .310). However, when considering the assessment, it was found that the average scores of before, during, and after study assessments, students had a different level of overall attitude and information, media and technology literacy with statistical significance at the .05 level (F = 79.438, 156.455; *sig* = .000, .000). The average scores after the study were the highest. Details are shown in Figures 6 and 7.

Table 3. Skills in information, media, and technology literacy

21st-century learning skills	Assessment								
	Before study			During the study			After study		
	M	*SD*	Level	*M*	*SD*	Level	*M*	*SD*	Level
1. Attitude	1.98	0.30	Low	3.10	0.24	Medium	4.82	0.15	Highest
2. Skills in information, media and technology									
2.1 Information literacy	1.94	0.30	Low	3.12	0.07	Medium	4.91	0.06	Highest
2.2 Media literacy	2.11	0.38	Low	3.22	0.15	Medium	4.57	0.17	Highest
2.3 Technology literacy	2.26	0.35	Low	3.13	0.23	Medium	4.87	0.23	Highest
Overall	2.10	0.24	Low	3.16	0.10	Medium	4.78	0.10	Highest

Figure 6. Overall skills in information, media, and ICT literacy

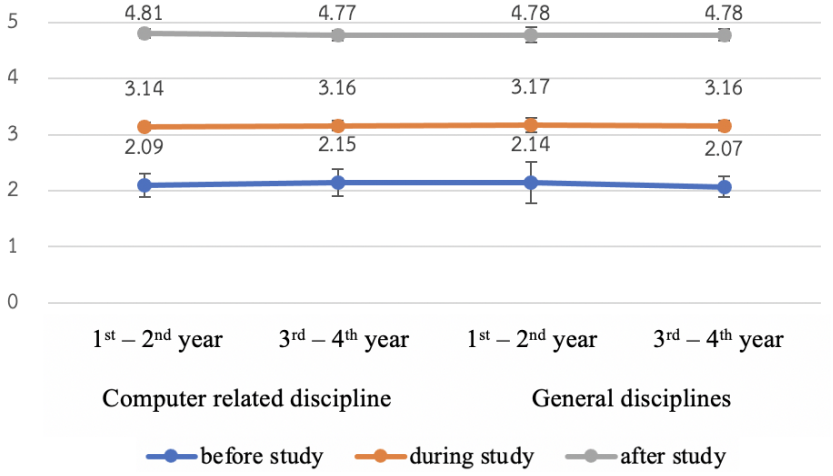
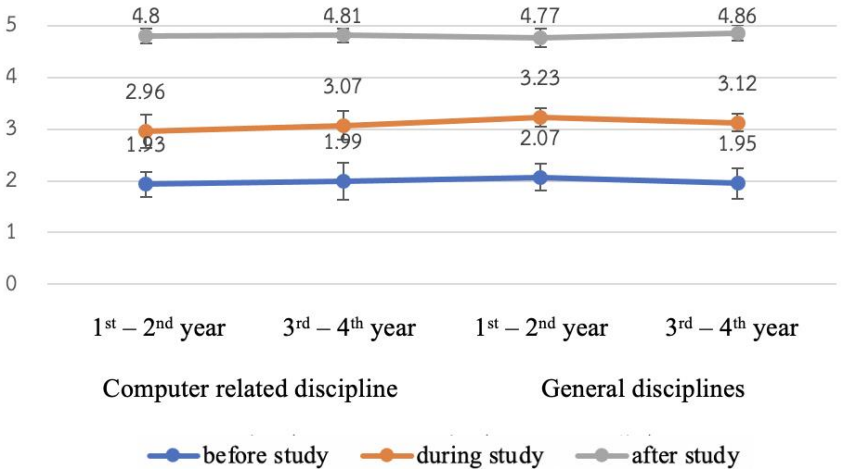


Figure 7. Overall attitude



4.2. Analysis of the results of opinion analysis on skills in information, media, and ICT

Data analysis results on the opinions about information, media, and technology literacy before, during and after study found that the students had the highest level of opinions and behaviors on information, media, and ICT literacy after the study, as shown in Table 4.

Table 4. Level of opinions and behaviors on information, media, and technology literacy

Information, media, and Technology literacy	Full score	Assessment					
		Before study		During the study		After study	
		M	*SD*	*M*	*SD*	*M*	*SD*
Level of opinions	5	2.33	0.25	3.68	0.25	4.83	0.13
Level of behaviors	10	8.54	1.00	9.43	0.72	9.81	0.49

Table 5. The level of opinions and behaviors on information, media, and ICT literacy, classified by the field of study and year of study

Information, media, and technology literacy	Field of study	Year of study	Full score	Assessment					
				Before study		During the study		After study	
				M	*SD*	*M*	*SD*	*M*	*SD*
Level of opinions	Computer-related discipline	1–2	5	2.34	0.19	3.63	0.33	4.86	0.08
		3–4	5	2.30	0.28	3.71	0.18	4.79	0.13
	General disciplines	1–2	5	2.38	0.20	3.68	0.23	4.82	0.16
		3–4	5	2.33	0.28	3.69	0.26	4.84	0.14
Level of behaviors	Computer-related discipline	1–2	10	8.56	0.81	9.37	0.72	9.94	0.25
		3–4	10	8.57	1.20	9.52	0.79	9.65	0.71
	General disciplines	1–2	10	8.47	1.01	9.24	0.56	9.71	0.47
		3–4	10	8.54	0.98	9.49	0.75	9.90	0.37

Figure 8. Level of opinions on information, media, and ICT literacy

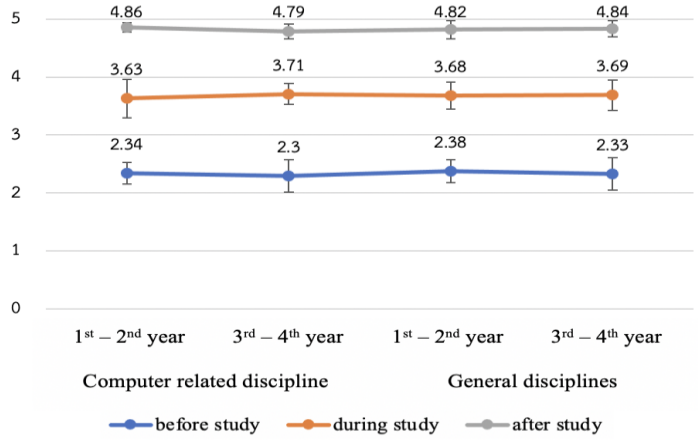
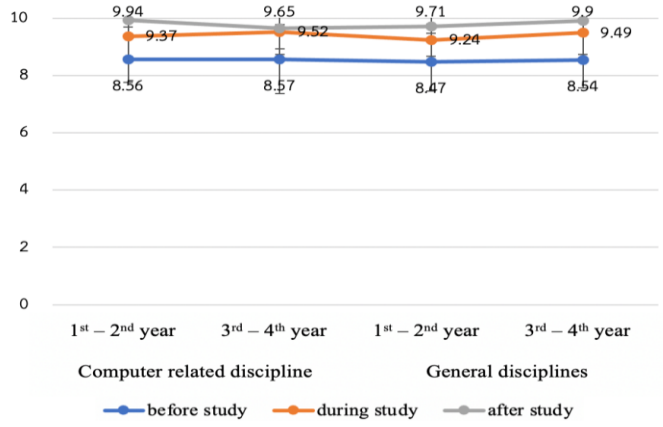


Figure 9. Level of behaviors on information, media, and ICT literacy



When classified by the field of study and year of study, with experience in using computers as an extraneous variable, it was found that variables of a field of study and year did not affect the level of opinions and behaviors on information, media, and technology literacy with statistical significance at the .05 level (F = .780, .793; sig = .460, .454). However, the assessment found that students had a different level of opinions and behaviors on information, media, and technology literacy before, during, and after the study with statistical significance at the .05 level (F = 193.305, 4.189; sig = .000, .000). The opinions and behaviors on information, media, and technology literacy after the study had the highest level, as shown in Table 5. Details are shown in Figures 8 and 9.

4.3. Analysis of results of performance assessment in information, media, and technology literacy using the rubrics assessment criteria

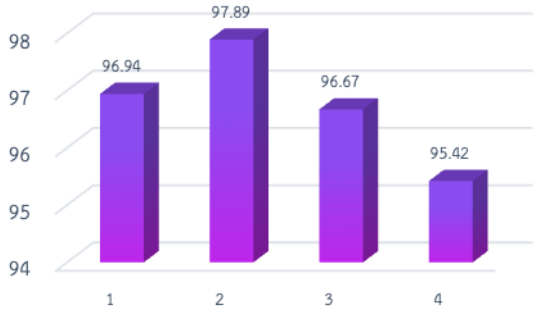
Performance assessment by teachers using the rubrics assessment criteria in information, media, and ICT literacy found that students had overall scores at a good level (M = 90.16, SD = 2.10). When assessing each item, it was found that students had average scores in information literacy, media literacy, and technology literacy and social skills at a good level in every skill (M = 29.08, 23.49, 29.00, 8.59; SD = 0.83, 0.58, 1.22, 0.52), as shown in Figure 10. Sample work and written reflections are shown in Figure 11.

In addition, there was an assessment of information, media, and ICT literacy by using pre-test and post-test. The results of the data analysis revealed that students had higher average scores after the study with statistical significance at the .05 level (t = 26.447, sig = .000), as shown in Table 6.

Table 6. Analysis results of differences in average scores before and after study

Assessment	Full score	*M*	*SD*	*t*-test	*sig*	Result
Before study	10	6.16	0.95	26.447	.000	After > Before
After study	10	9.32	0.74			

Figure 10. Literacy percentage of performance assessment score level



Note. 1 = Information literacy, 2 = Media literacy, 3 = ICT literacy, 4 = soft skills

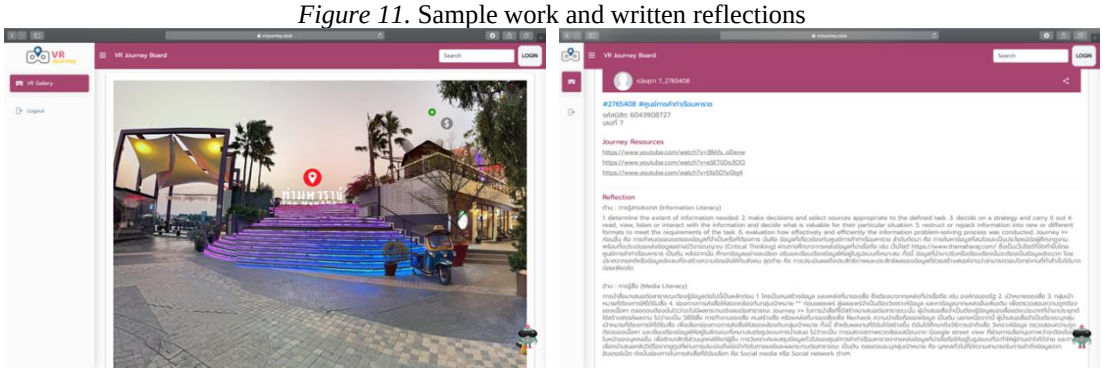
Some answers from the interviews of VR Journal users:

"Using flipped classroom learning theory with self-directed learning via lecture videos effectively promotes flexibility in learning as learners can learn anywhere, anytime, and as many times as they need."
An undergraduate student in a non-educational technology-related major

"During the COVID-19 pandemic, I realized the significant role of technology in online learning. Also, it is essential to design learning activities that promote learner engagement, resulting in learners' motivation and discipline."
An undergraduate student in a non-educational technology-related major

"Creating interactions between learners and teachers through learning activities and conducting cumulative learning activities, such as keeping reflective learning logs of what they have learned and how they can expand it, can create active learning, knowledge retention, and, finally, actual construction of knowledge."
An undergraduate student in an educational technology-related major

Figure 11. Sample work and written reflections



5. Discussion

The analysis of twenty-first-century learning skills in information, media and ICT literacy revealed that students had twenty-first-century learning skills in information, media and ICT literacy after study in every skill at the highest level. The innovation-based virtual flipped learning system allowed students to study the content on their own by watching streaming videos which the students prepared before class. A chatbot was used as a learning assistant. It presented learning steps and helped students to access learning resources conveniently. Students can receive feedback from activities through a chatbot. Therefore, students who had limited computer experience could easily learn and carry out activities. This is consistent with the research by Mckie and Narayan (2019) that used chatbots to create learning experiences for learners. The study found that the use of chatbots in higher education was convenient and made students feel confident to use them. In addition, the use of chatbots also allowed students to monitor their own learning progress and access learning content easily (Smutny & Schreiberova, 2020; Kuhail et al., 2023). This study also investigated the background of students from different majors, divided into two groups: (1) computer-related disciplines and (2) general disciplines. The findings revealed that teachers, instructional designers, and researchers could use this innovation with students of all majors, including IT-related majors and others, to develop students' skills in information literacy, media, and technology. Teachers could make practical use of this innovation in their subjects by allowing students to study the content on their own or using it as part of the lessons. As this technology was flexible and learning resources and activities were easy to access, using this technology with chatbots would enable students to learn anywhere, anytime, responding to the personal learning styles of students (Kaiss et al., 2023). In addition, this study looked further into the details of skills in three areas: information literacy, media literacy, and information and communication technology literacy are as follows.

Information literacy. Students in the later years of study had higher information literacy. When considering the variable in the field of study, students who studied in general disciplines had higher average scores than those who studied in a computer-related discipline. This reflects the fact that this developed innovation can be applied to general students and need not be limited to students in the field of a computer-related discipline. After having completed self-study through video streaming, students conducted self-assessment and reflection of information literacy and additional resources they had consulted. This is consistent with research by Gómez-García et al. (2020), reviewing the literature on how to apply flipped classroom learning to improve information literacy. The results of the study revealed that the design of activities focused on the students' participation in learning and self-control in learning. The system allowed students to learn by watching videos and animation media. Learning in modules can improve information literacy.

Media literacy. Learning innovations encouraged students to reflect and search for more information and create work using Thinglink. This is in line with research by Rajagopal et al. (2020) that designed learning in a virtual learning environment that allowed students to carry out activities together. The results showed that a virtual learning environment can promote learners' media literacy.

Information, Communication and Technology literacy. Data analysis showed that students had the highest information technology and communication literacy after the study. An innovation-based virtual flipped learning system-developed information technology and communication literacy by allowing students to reflect and search for additional information and create works using Thinglink. This is the application of knowledge gained from learning to create work in a virtual format. It is in line with Torres-Madroñero et al. (2020), which discussed the use of digital tools, virtual tools, and reflective activity design to develop students' information technology and communication literacy.

Attitude. Data analysis found that students had better learning attitudes after the study than during and before the study. It showed that the innovation-based virtual flipped learning system could motivate learning through participation in activities and self-direct learning by searching for information and creating works according to one's interest. The design employed various virtual tools, including the use of chatbots to help students learn (Alnasib & Ali, 2020; Morris & McDermott, 2022; Smutny & Schreiberova, 2020).

6. Conclusion

The research on an innovation-based virtual flipped learning system in a ULE to enhance twenty-first-century learning skills in information, media, and technology of higher education learners used DBR. The researcher collected information on the user UX to be initial data in the design together with design principles and learning theories. The research results found that the innovation can enhance twenty-first-century learning skills in information, media and technology literacy and improve learners' attitudes. This innovation can be used with learners in various contexts, such as learners with experience in using technology and those studying in different fields. The innovation can be integrated into classroom activities and used as additional learning resources to help learners develop their twenty-first-century learning skills in information, media, and technology literacy wherever and whenever they wish. The system can be applied to students in all disciplines to develop information, media, and technology literacy. Teachers can apply this innovation in their courses by having students study the content on their own. It can also be used as a part of teaching and learning management in the course. This innovation offers flexible learning and allows convenient access to learning resources and activities. Students can learn anywhere and anytime with the use of chatbots that meet their individual learning needs.

However, the results of the data analysis revealed that when considering the field of study and year of study, with experience in using computers as an extraneous variable, students' information, media, and technology literacy did not affect their attitudes and information, media and technology literacy. Therefore, a future study may look at other extraneous variables such as the learning success rate and learning behaviors to gain more insight into the learner's user experience, leading to the development of innovation for optimal efficiency.

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Authors' contributions

JK and TT conceived and designed the experiments, and JK performed the experiments. JK and TT analyzed and interpreted the data. JK and TT contributed reagents, materials, analysis tools, or data; and JK and TT wrote the paper. All authors have read and approved the final manuscript.

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Declarations

Ethical considerations

In this study, the researchers have obtained consent from the participants to give their responses. The informed consent forms were distributed to the teachers involved in our survey, and the signed privacy consent forms were collected. The researchers ensured the anonymity of the participants as well as their freedom to withdraw from

the study at any time with no need to give reasons. The data were kept during the study and destroyed upon completion of the study. Only researchers had access to the data.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no competing interests.

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