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The Development of an Instructional Model Based on Flipped Using Technology-Based Learning to Enhance the Digital Literacy for Undergraduate Students in the Faculty of Education, Rajabhat University

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Abstract

Research objectives were to 1) investigate the current state and best practice of the instruction relying on flipped learning; 2) develop the instructional model based on flipped using technology-based learning to enhance the digital literacy for undergraduate students of Rajabhat University and 3) examine the effects of the model. The sample for fulfilling the 1st objective contained 119 instructors teaching educational technology or related fields within the faculty, 397 students, and 10 experts. Data were collected through 60 first-year students and three types of research tools: the developed model, a test of digital literacy, and a satisfaction questionnaire. Descriptive statistics, that is, arithmetic mean, standard deviation, and t-test were employed in data analysis. The research findings were as follows: 1) The current state of the instruction resulted from the instructors was found to be at an overall lower level (M = 2.43, SD = 0.63) as well as of the students (M = 2.46, SD = 0.65). The participants reflected that the best practice of the instruction included the flipped learning model and learning processes using technologies. 2) The developed model consisted of principle; objectives; learning processes; media, technologies and learning sources; and evaluation. Flipped learning included online and on-site approaches. Learning processes included 6 stages: making knowing learning process; studying from technologies and online learning sources; reflecting and questioning memos; exchanging knowledge; producing tasks; and evaluating. 3) The results of using the developed model showed that 3.1) digital literacy of the students after learning was found to be significantly higher than that of before the study at 0.05; 2) digital literacy of the students in the experiment group was found to be significantly higher than that of the control group at 0.05; and 3) students' satisfaction was found to be positively highest level (M = 4.81, SD = 0.22).

Keywords: development of instruction, digital literacy, flipped learning, instructional model, technology-based learning

1. Introduction

In 2022, the Thailand Development Research Institute (TDRI) identified a critical skills gap in the country's digital workforce. Their findings indicated that a significant portion of Thai graduates possess skills that do not align with the demands of the Information and Communications Technology (ICT) industry, rendering them ill-equipped for employment in this sector. This deficiency was further corroborated by the IMD (International Institute for Management Development)'s 2021 Digital Competitiveness Ranking, which placed Thailand at the bottom of the list, reflecting a continuous decline in the country's training and education capabilities. This concerning situation prompted the Thai government to embark on a transformative journey towards a digital economy and society, recognizing the imperative of enhancing the digital literacy and skills of its citizens. To address this pressing issue, the government formulated the National Digital Development Strategy for Economy and Society (A.D. 2018-2037). This comprehensive strategy encompasses five key pillars, with the fifth specifically focused on developing a digital-ready workforce. This strategic pillar outlines a roadmap for cultivating a digitally skilled population equipped to thrive in the emerging digital era.

To respond to the government policies, the Office of the Higher Education Commission (OHEC) has issued guidelines for implementing the National Higher Education Qualifications Framework (NHEQF) B.E. 2552, which specifies digital competencies for bachelor's degree graduates. These graduates must possess the qualifications or competencies specified in Learning Outcome Standard 5, which includes analytical, communication, and information technology skills, both in terms of producing and using technology for education. They must have the knowledge, abilities, and skills to produce and use technology effectively. The OHEC has mandated that higher education institutions administer digital competency tests to students using internationally standardized tests or as determined by the university. This includes internal quality assurance at both the faculty and institutional levels. In the academic year 2564, the Graduate Production Component has defined Indicator 1.7 as the promotion of digital competencies and skills, and it has evaluation criteria in Section 5. The target is that at least 50% of final-year undergraduate students should pass the IC3 or equivalent or as determined by the university. Thai scholars have proposed three aspects of digital literacy at the individual level: 1) Use, 2) Understanding, and 3) Creation. This is because digital literacy is a fundamental basis that enables individuals to use technology and digital media to learn effectively and to solve problems in various situations that arise in education and daily life (Suksangprasit et al., 2022). To align human resource development with national and university directions and policies, universities have been refining teaching and learning formats that can be used both in and out of the classroom, as well as diverse teaching materials. In the field of Instructional Design, most educational technologists, such as Joyce & Weil (2004); Dick & Carey (2005); and Kemp (2010) design models or teaching formats that focus on creating learning experiences that respond to the needs and objectives of learners, as exemplified by (Gerlach & Ely, 1971; Wathananarong, 2006; & Seechaliao, 2010). This process consists of the following main steps: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation.

Flipped learning constitutes a pedagogical approach where students engage in independent knowledge acquisition through online resources outside the classroom. This self-directed learning phase precedes structured in-class activities, often facilitated by the instructor who provides guidance and support (Nantha, 2022). The learning materials themselves encompass diverse online channels, including websites, YouTube, and social media platforms. These resources leverage the inherent versatility of technology to deliver content across various domains (Hongthong et al., 2021). In-class activities promote interaction and collaboration among students and the instructor. These may involve discussions centered around the pre-studied material, or group projects designed to deepen understanding. The effectiveness of flipped learning hinges on the engaging nature of the learning resources and the participatory nature of both the online and in-class components (Watthanatam, 2020). Effective flipped learning strategies emphasize the delivery of information in a clear and comprehensible format. This includes the incorporation of formative assessments that students can utilize to gauge their grasp of the material (Yipeng, 2022). Additionally, opportunities are provided for students who require further clarification to seek assistance from the instructor or engage in peer-to-peer learning discussions. This fosters an environment conducive to collaborative knowledge construction, a hallmark of effective flipped classrooms. The aforementioned instructional model underscores the centrality of technology-based learning (TBL). TBL encompasses the strategic integration of technological tools and media to enhance student learning experiences (Joyce & Weil, 2004). This includes the utilization of various technological resources, ranging from computers and digital learning platforms to potentially more advanced tools like virtual reality applications (Haleem et al., 2022). Ultimately, TBL aims to empower learners to assume a more active role in the learning process, fostering a shift towards collaborative knowledge acquisition.

Recognizing the critical role of digital literacy and flipped classroom pedagogy in undergraduate education, this study presents the development of a technology-based flipped instructional model. This model specifically targets undergraduate students within the Faculty of Education at Rajabhat University. The model's primary function is to enhance student digital literacy and is intended to serve as a guiding framework for future teaching and learning endeavors.

2. Method

2.1 Research Objectives

- to investigate the current state of flipped classroom pedagogy, specifically focusing on best practices that leverage technology as a foundation
- to develop and implement the instructional model based on flipped using technology-based learning to enhance the digital literacy for undergraduate students of Rajabhat University
- to assess the effectiveness of the developed model in enhancing the digital literacy of undergraduate students

of Rajabhat University

2.2 Research Hypothesis

- Undergraduate students in the Faculty of Education at Rajabhat University who participate in the developed model will exhibit higher levels of digital literacy after the intervention compared to their digital literacy levels prior to the intervention.
- The digital literacy of students assigned to the experimental group, who will be engaged in the developed model, will be superior to the digital literacy of students assigned to the control group, who will receive traditional classroom instruction.

2.3 Research Method

Research and Development (R&D) methodology was conducted in 3 phases as follows:

2.3.1 Phase 1

The initial phase focuses on establishing the current state of flipped classroom implementation and identifying best practices. This phase employs a multi-pronged approach: 1) A comprehensive review of existing research, concepts, principles, and theories related to flipped classrooms will be conducted to synthesize the core elements of this pedagogical model. 2) A survey will be administered to instructors and students from the Faculty of Education at Rajabhat University to gauge their perceptions of current teaching and learning practices. This will help identify potential areas for improvement that the flipped instructional model could address. 3) Semi-structured interviews will be conducted with experts to gather insights into best practices for implementing flipped classrooms effectively. The target sample groups for this phase included: Faculty members teaching Educational Technology or related fields within the Faculty of Education at Rajabhat University (n=119). Educational experts with a minimum of five years of teaching or relevant work experience or holding academic positions at the assistant professor level or above (n=10). This multi-faceted approach will provide a comprehensive understanding of the current landscape of flipped classroom implementation, identify pedagogical needs, and gather valuable insights from experts to inform the subsequent phases of the research project.

Research Instruments

- Teacher and Student Opinion Questionnaire: A self-administered questionnaire was employed to gauge the perceptions of both teachers and students. The instrument utilized a four-point Likert-type rating scale (Chang, 1993; Thomas, Mark, & Ruth, 1998, as cited in Rungson, 2006) to ensure consistency with the research objectives and content. Content validity was established through expert evaluation. Five experts independently assessed the questionnaire, and all items achieved a content validity index (CVI) between 0.60 and 1.00, indicating appropriate quality.
- Expert Interview Form: To explore best practices in technology-based flipped classroom design, a semi-structured interview format was developed. Similar to the questionnaire, content validity was assessed by five experts. Each expert reviewed the interview questions to ensure alignment with the research objectives and content. Following this evaluation, all interview questions achieved a CVI between 0.60 and 1.00, signifying their appropriateness.

Data Collection and Data Analysis

- Data collection occurred between April 10th, 2021, and December 31st, 2021. Descriptive statistical analysis was employed to analyze the collected data. This included calculating percentages, means, and standard deviations. Additionally, a descriptive narrative approach was used to interpret the findings.

2.3.2 Phase 2

This phase focused on the development and evaluation of the instructional model based on flipped using technology-based learning to enhance the digital literacy for undergraduate students enrolled in the Faculty of Education at Rajabhat University. The development process comprised four distinct steps: 1) Model Construction: This stage involved the initial conceptualization and drafting of the flipped instructional model. The model leveraged technology as a foundational element to specifically address the digital literacy development of the target student population. 2) Teaching Manual Creation: A comprehensive manual outlining the implementation of the flipped instructional model was developed to guide educators in its effective use. 3) Model Evaluation by Expert Panel: The suitability and effectiveness of the draft model were assessed by a panel of seven experts. The selection of these experts employed a rigorous method to ensure a diversity of perspectives. The panel comprised specialists in curriculum and instruction, educational technology and communication, and measurement and

evaluation. 4) Model Refinement and Certification: Based on the feedback received from the expert panel, the model was further refined and assessed for final certification. While the composition of the evaluation panel remains the same (experts in curriculum and instruction, educational technology and communication, and measurement and evaluation), a specific selection method will be employed to ensure a representative sample of expertise within each domain.

Research Instruments

- A researcher-designed questionnaire served as the primary instrument for evaluating the suitability of the draft instructional model. This instrument employed a 5-point Likert scale to gauge participant responses. The instrument's content validity was established through a quality check conducted by five experts. The experts' evaluation yielded inter-item reliability coefficients ranging from 0.80 to 1.00, signifying high internal consistency and the instrument's overall quality.

Data Collection and Data Analysis

- Data collection for this study occurred between August 20, 2022, and October 2, 2022, utilizing a semi-structured interview format. The interview data were subjected to a thematic analysis approach. This involved a meticulous process of summarizing key themes and patterns emerging from the transcribed interviews. Descriptive statistics, including percentages, means, and standard deviations, were employed to further analyze the quantitative data obtained through the questionnaire. Finally, a descriptive analysis of the qualitative data from the interviews was conducted to glean deeper insights into participants' perspectives. These combined findings informed the iterative refinement of the draft teaching model.

2.3.2 Phase 3

This section details the third phase of the research, which investigated the efficacy of the instructional model based on flipped using technology-based learning to enhance the digital literacy for undergraduate students. The study was conducted within the Faculty of Education at Rajabhat University, targeting first-year students enrolled in the course "Innovation and Information Technology for Communication, Education and Learning" (course code: 1031302) during the second semester of the 2022 academic year. A quasi-experimental design was employed, utilizing two groups of social studies majors; Group 9 (n=30) served as the experimental group and received instruction through a flipped instructional model that leveraged technology to promote digital literacy skills; conversely, Group 10 (n=30) functioned as the control group and received instruction through a traditional lecture-based method. The curriculum was divided into five distinct learning units focusing on 1) Principles, concepts, and theoretical frameworks pertaining to innovation and information technology within communication, education, and learning contexts 2) Learning theory and principles 3) Ethical and intellectual property law 4) Utilizing a word processing program 5) Utilizing a presentation program. The intervention period spanned six weeks, commencing on December 5th, 2022, and concluding on January 9th, 2023.

Research Instruments

- This study employed the instructional model based on flipped using technology-based learning to enhance the digital literacy of undergraduate students who enrolled in the Faculty of Education at Rajabhat University. The model was implemented over a six-week period with the experimental group, with each class session lasting 3 hours and 20 minutes. A total of six lesson plans were developed, adhering to the flipped classroom approach. The quality of the lesson plans was evaluated using a five-point Likert scale by a panel of six experts. The mean score for the overall learning management plan was 4.60, with a standard deviation of 0.14. Based on established interpretation criteria for Likert scale data, this score indicates a very high level of appropriateness for the learning materials and instructional design.
- To assess the impact of the intervention, a standardized digital literacy test was administered to both the experimental and control groups before and after the instructional period. This test evaluated participants' proficiency across eight key digital literacy domains: 1) Basic Digital Knowledge and Information: Understanding of fundamental digital concepts and information structures. 2) Access: Ability to locate and retrieve information from digital resources. 3) Management: Skills in organizing, storing, and retrieving digital information effectively. 4) Integration: Capacity to combine digital information from various sources. 5) Communication: Effective communication and collaboration using digital tools. 6) Creativity: Competence in utilizing digital tools for creative expression and problem-solving. 7) Awareness: Understanding of digital citizenship, safety, and ethics. 8) Evaluation: Ability to critically analyze and assess the credibility of digital information. To ensure the test accurately measured the intended digital literacy constructs, an index of concordance (IOC) was employed. Five experts reviewed the test items, and their

judgments were analyzed using the method outlined by Rovinelli and Hambleton, 1977, as cited in Phonphotthanamat (2022). The IOC indicated a high degree of agreement (between 0.8 and 1.00) among the experts regarding the relevance of the questions to the core digital literacy domains. The test's internal consistency was further established by administering it to a separate group of 30 participants (not part of the experimental or control groups). This pilot administration facilitated the analysis of item difficulty (p-value), discriminatory power (r-value), and subsequently, the selection of 60 optimal items. The ideal difficulty range for these items was set between 0.20 and 0.80, with a discriminatory power of 0.20 or above. To assess the overall reliability of the test, Kuder Richardson's KR-20 and Cronbach's alpha reliability coefficients were calculated. Both measures exceeded the desired threshold of 0.70, with the total reliability reaching an impressive value of 0.929. This confirms that the digital literacy test possesses strong internal consistency and is a reliable instrument for measuring digital literacy proficiency.

- A student satisfaction assessment form was developed to evaluate the implementation of the instructional model. This form utilized a 5-point Likert scale to gather student feedback. The instrument underwent a rigorous quality check by a panel of five experts. The content validity of the instrument was established, with all items demonstrating a high degree of clarity and relevance (item-to-contest validity coefficients between 0.80 and 1.00).

Data Collection and Data Analysis

- The Digital Literacy Test and satisfaction assessment form, the core instruments used for data collection, were subjected to rigorous evaluation by six experts to ensure their content validity and reliability. Descriptive statistics, including percentages, means, and standard deviations, were calculated to analyze the expert feedback. Additionally, a qualitative analysis of the feedback was conducted to glean further insights into the instruments' strengths and weaknesses.
- The teaching and learning plan was implemented following the format established for the experimental group. Data was collected throughout the intervention period. Similar to the instrument evaluation, descriptive statistical analysis (percentages, means, and standard deviations) was employed to summarize the obtained data. A qualitative analysis of the data was also performed to provide a more nuanced understanding of the teaching and learning experience.
- Digital literacy tests were administered to both the experimental and control groups. A pre-test and post-test design was utilized to assess the impact of the intervention on the experimental group's digital literacy skills. The collected data underwent a two-pronged analysis approach. 1) A dependent t-test was conducted to examine the pre-test and post-test scores within the experimental group. This analysis aimed to determine if a statistically significant improvement in digital literacy knowledge occurred following the intervention. 2) An independent t-test was employed to compare the post-test scores between the experimental and control groups. This analysis aimed to identify a statistically significant difference in digital literacy skills between the group that received the intervention and the control group.

2.4 Ethical Considerations

This research study was approved by Mahasarakham University Ethics Committee for Research Involving Human Subjects (No. 269/2020, issued on 13 November 2020). All data were kept confidential.

3. Results

3.1 Current Conditions and Best Practices

The analysis explored teacher and student perceptions of current practices in flipped classrooms utilizing technology. Scores were categorized by domain (measurement & evaluation, teaching media, and methods & activities) and averaged across participants.

Teacher Perceptions: The overall mean score ($M = 2.43$, $SD = 0.63$) indicated a generally favorable view of current conditions. Measurement & evaluation received the highest average score ($M = 2.47$, $SD = 0.64$), followed by teaching media ($M = 2.45$, $SD = 0.63$) and methods & activities ($M = 2.39$, $SD = 0.63$).

Student Perceptions: Similar to teachers, students reported a positive outlook on technology-based flipped learning ($M = 2.46$, $SD = 0.65$). The measurement & evaluation domain received the highest score ($M = 2.56$, $SD = 0.71$), followed by teaching media ($M = 2.53$, $SD = 0.70$) and methods & activities ($M = 2.34$, $SD = 0.56$).

Additionally, expert opinions on best practices for the flipped instructional model were gathered. These key elements emerged: 1) Blended Learning: The model combines face-to-face instruction with online content delivery. 2) Learning Management Steps: These steps guide the learning process: understanding objectives,

exploring technological media and resources, reflecting and recording questions, knowledge exchange and production of work, and evaluating learning outcomes. 3) Technology Integration: The model emphasizes various educational technologies, including information search, communication, work development, presentation, classroom management, and data storage tools.

3.2 Developed the Instructional Model Based on Flipped Using Technology-based Learning to Enhance the Digital Literacy for Undergraduate Students of Rajabhat University

This section details the newly developed technology-based flipped instructional model designed to enhance digital literacy among undergraduate students in the Faculty of Education at Rajabhat University. The model is structured around the following components: 1) Principles: These principles reflect the core tenets of technology-based flipped teaching and digital literacy development. 2) Learning Objectives: The model outlines specific learning goals for students. 3) Components: The model incorporates key elements for effective flipped classroom implementation. 4) Steps: Each step guides students through the learning process, specifying appropriate educational technologies based on the activity and learning resources. The model integrates six technology categories based on their usage: 1) Information Search (e.g., Google Search) 2) Communication (e.g., Facebook) 3) Work Development (e.g., Microsoft Word, Google Docs, Slides) 4) Presentation (e.g., YouTube, Jamboard, Canva, Kinemaster, OBS Studio) 5) Classroom Management (e.g., Google Classroom, Kahoot, Padlet, Quizlet, Quizizz, Poll Everywhere) 6) Data Storage (e.g., Google Drive, Forms)

A visual representation of the model and its components can be found in Figure 1.

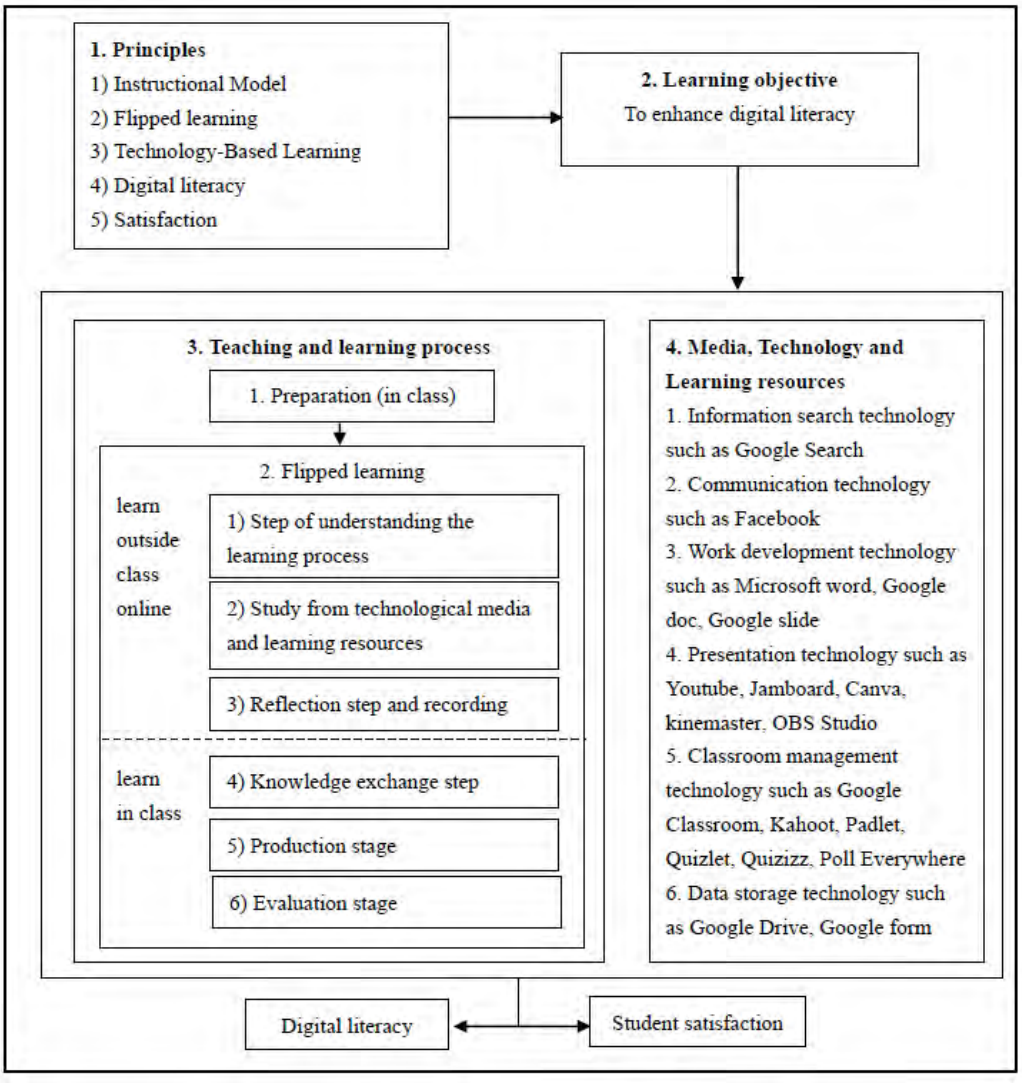

Figure 1. A schematic representation of the instructional model based on flipped using technology-based learning to enhance the digital literacy for undergraduate students of Rajabhat University

The evaluation and certification process conducted by subject matter experts yielded the following key components of the instructional model: 1. Alignment with Current Undergraduate Education: The model demonstrates a high degree of congruency with contemporary teaching and learning practices at the undergraduate level. 2) Theoretical Foundation: The model is demonstrably grounded in a comprehensive framework of principles, concepts, and relevant educational theories. 3) Explicit Aims and Objectives: The model clearly outlines its guiding principles and intended student learning outcomes. 4) Visual Representation: A comprehensive model diagram provides a clear visual representation of the model's structure and flow. 5) Core Components: The essential elements that comprise the model are clearly identified and defined. 6) Instructional Design Steps: The model incorporates a well-defined sequence of instructional design steps. The expert evaluation yielded an overall rating of "very appropriate" with a mean score of M = 4.35 and a standard deviation of S.D. = 0.43, indicating a high level of consensus among the reviewers regarding the model's effectiveness.

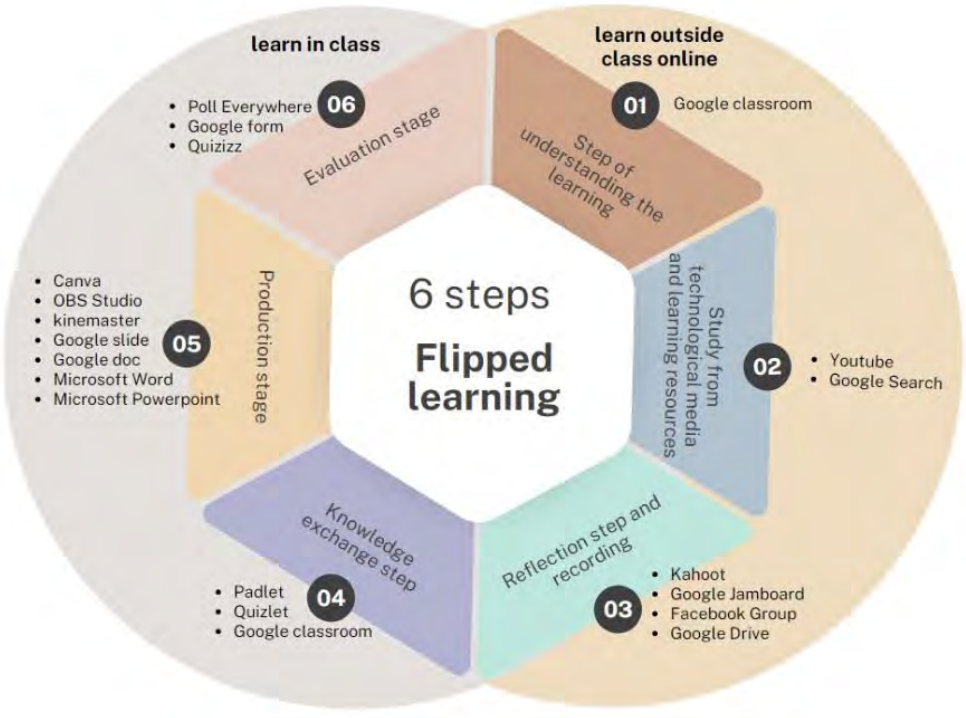

Figure 2. Flipped learning stages with different specific technologies and tools

As shown in figure 2, different specific technologies and tools were used in both online learning and in-class learning. Details on how they were utilized in six stages of the developed model were indicated as the following.

Stage 1: Beyond Classroom Study (Online learning)

The instructor prepared the explanation of ‘how to learn’ and put it on to Google classroom in order that the students were able to study before doing in-classroom activities.

Stage 2: Online Tools Selection (Online learning)

The instructor prepared the needed contents on Youtube or had the students additionally study on Google search.

Stage 3: Reflection and Question Note-Taking (Online learning)

The students commented or questioned by using Kahoot, Google Jamboard, Facebook Group, and Google Drive.

Stage 4: Knowledge Exchange (In-class learning)

The students exchanged their understanding with classmates together with the instructor until the conclusion was met.

Stage 5: Work Production (In-class learning)

The students produced their workpieces by choosing the specific tools assigned by the instructor, i.e. Canva,

OBS Studio, Kinemaster, Google Slide, Google doc, Microsoft Word, or Microsoft PowerPoint

Stage 6: Workpiece Evaluation (In-class learning)

The instructor constructed a workpiece evaluation form and allowed the students to evaluate their classmates' production.

3.3 Impact of the Instructional Model Based on Flipped Using Technology-based Learning on Digital Literacy

This section presents the findings related to the effectiveness of the technology-based flipped instructional model in enhancing digital literacy among undergraduate students in the Faculty of Education at Rajabhat University.

3.3.1 Pre-test and Post-test Digital Literacy Scores in the Experimental Group

The analysis focuses on the changes in digital literacy competence within the experimental group.

Table 1. The comparative results of pre-test and post-test digital literacy average scores achieved by the students who participated in the flipped using technology-based learning intervention

Scores	n	M	S.D.	df	t	p-value
Pre-Test (60)	30	10.27	1.82	29	28.335	.000
Post-Test (60)	30	24.03	2.11			

*p<.05

Data analysis of Table 1 reveals a positive correlation between the developed instructional model and the enhancement of students' digital literacy. This finding is particularly evident among undergraduate students enrolled in the Faculty of Education at Rajabhat University. Their average digital literacy scores exhibited a statistically significant increase ($p < .05$) following the implementation of the flipped instructional model compared to their scores prior to the intervention.

3.3.2 Analysis of Digital Literacy Scores: Experimental vs. Control Group

This explores the comparative analysis of digital literacy scores between students who participated in the experimental group's teaching method and those in the control group receiving the standard teaching method. The results are presented in Table 2.

Table 2. Specifically focuses on the post-test digital literacy scores, aiming to identify any significant differences in student achievement between the two groups

Scores	n	M	S.D.	df	t	p-value
Experimental Group (60)	30	24.03	2.11	58	10.327	.000
Control Group (60)	30	18.37	2.14			

*p<.05

Data presented in Table 2 reveals a statistically significant difference ($p < .05$) in the digital literacy scores between students instructed using the experimental instructional model and those receiving the control group's standard instruction.

3.3.3 Analysis of the Developed Model Reveals a High Overall Level of Student Satisfaction with Learning ($M = 4.81$, $SD = 0.22$)

Delving deeper into specific elements, the data indicates that students expressed the strongest satisfaction with three key aspects: 1) Orientation Regarding Teaching Format: Students reported the highest level of satisfaction ($M = 5.00$, $SD = 0.00$) with receiving clear introductory information about the structure and organization of teaching activities within the course. 2) Reflective Learning Activities: Students were highly satisfied ($M = 5.00$, $SD = 0.00$) with the incorporation of activities that encouraged reflection and question recording, as these facilitated personal note-taking and learning consolidation. 3) Digital Technology Integration: Students expressed a strong level of satisfaction ($M = 4.93$, $SD = 0.25$) with opportunities to develop their skills in utilizing digital technologies across various applications.

4. Discussion

The instructional model based on flipped using technology-based learning designed to cultivate digital literacy among undergraduate students in the Faculty of Education at Rajabhat University comprises five key elements: 1) Principles: This outlines the fundamental pedagogical underpinnings of the model. 2) Objectives: This clearly

defines the intended learning outcomes for students. 3) Teaching and Learning Process: This details the instructional activities undertaken within the model. 4) Media, Technology, and Learning Resources: This specifies the technological tools and resources employed in the model. 5) Measurement and Evaluation: This outlines the methods used to assess student learning and the model's effectiveness. The learning management process within the model is a six-step cyclical approach divided into two phases:

Pre-Classroom Learning

- Step 1: Introduction to Learning Objectives - Students gain a comprehensive understanding of the learning goals and desired outcomes.
- Step 2: Exploration Through Technology - Students engage with digital media and online learning resources to acquire foundational knowledge.
- Step 3: Reflection and Question Formulation - Students critically reflect on the learning materials and formulate questions for further exploration.

In-Classroom Learning

- Step 4: Knowledge Sharing - Students actively participate in knowledge exchange through discussions and presentations.
- Step 5: Project-Based Learning - Students apply their acquired knowledge to create projects that demonstrate their learning.
- Step 6: Formative Assessment - Students receive feedback through evaluation forms completed by experts, leading to continuous improvement.

The model aligns with current research on effective instructional models in Thai higher education. Studies investigating the development of models to enhance Thai language communication skills (Masard et al., 2023), foster innovative creativity in physical education (Khuana & Khuana, 2020), and create curriculum innovations using design thinking for master's students (Charoenchim et al., 2022) all highlight the importance of both well-defined model elements and a robust learning process. The proposed model integrates these crucial aspects to facilitate impactful student learning within a technology-rich environment.

Students who participated in the instructional model based on flipped using technology-based learning demonstrated significant improvement in their digital literacy scores, as evidenced by the pre-test and post-test results. Overall, the post-test scores indicated a high level of achievement. These findings suggest that the proposed model effectively enhances undergraduate students' digital literacy skills within the Faculty of Education at Rajabhat University. This aligns with the evaluations of seven experts who rated the model as "very good" and confirmed its appropriateness based on its adherence to technology-based flipped teaching principles. The success of this model aligns with existing research on flipped learning methodologies. Studies such as Nuntasri & Nuntasri (2023) explored flipped instruction with e-learning lessons combined with peer learning techniques, while Wattananualsakul et al. (2023) investigated flipped instruction in conjunction with cooperative learning to strengthen analytical thinking skills. Additionally, Lertbumroongchai & Channgam (2020) examined a cloud-based inverted gamification classroom to promote 21st-century learning skills. Sajjaboriboon (2020) explored flipped teaching combined with project-based collaborative KWDL techniques, and Wongnam et al. (2019) implemented a flipped classroom teaching package with flexible learning. Digital literacy constitutes a fundamental digital skill, equipping individuals with the essential capabilities to perform tasks, communicate effectively, and collaborate with others. In the context of Thailand 4.0, this skill set serves as a critical tool for students' learning and self-development, ultimately leading to improved career opportunities and professional advancement. The four key components of digital literacy are identified as: (1) Use, (2) Understand, (3) Create, and (4) Access. The results of this research concur with numerous existing studies. For instance, Singpraphai & Nasongkhla (2023) investigated remote internships in educational technology to promote digital literacy skills in pre-service teachers. Additionally, studies by Kulavijit (2022), Srichan (2022), and Chuenchom et al. (2021) explored the digital literacy of undergraduate students. Furthermore, the research aligns with the concept of digital literacy components proposed by Techataweewan & Prasertsin (2016) for Thai students. This framework incorporates four components: (1) Operational Skills, (2) Thinking Skills, (3) Collaboration Skills, and (4) Awareness Skills. The course content within the developed instructional model was structured into three distinct sections: (1) Computer Fundamentals, (2) Key Applications, and (3) Living in the Online World (Living Online).

This part analyzes the achievement scores and explores the potential reasons behind the observed difference between the flipped instructional model and the traditional teaching method. Students who participated in the format-based program achieved statistically significant higher scores in digital literacy compared to the control group. This disparity can be attributed to the inherent differences in the structure and delivery of learning

activities within each model. The flipped instructional model incorporates elements of flipped classroom pedagogy, which emphasizes a specific sequence of activities designed to enhance the learning experience. Arner (2020) outlines four key components of flipped classrooms: 1) Experiential Engagement, where students encounter concepts through introductory activities; 2) Concept Exploration, where students actively seek understanding through research; 3) Meaning-making, where students solidify knowledge through application; and 4) Demonstration & Application, where students demonstrate their comprehension through practical tasks. Saiyasit et al. (2021) provide a complementary framework for designing flipped classrooms, focusing on four key areas: 1) Course Objectives and Content, 2) Teaching Methods/Strategies, 3) Organizing the Learning Environment, and 4) Evaluating Learning Outcomes. This aligns with the research by Teachakaew et al. (2017) who explored the development of flipped classrooms to promote science communication skills. Their model incorporates out-of-classroom activities for Experiential Engagement and Concept Exploration, followed by in-classroom activities for Knowledge Development and Application. The effectiveness of the flipped instructional model is further supported by existing research on digital literacy skills in undergraduate populations. Srichan et al. (2020) compared digital literacy skills among students from 38 Rajabhat Universities in Thailand. They found significant differences in digital literacy levels across year groups and study subjects. Notably, students in science and liberal arts programs exhibited higher overall digital literacy compared to those in social sciences. Similarly, Chuennom et al. (2021) investigated the development of digital knowledge skills at Chiang Mai Rajabhat University. Their study measured digital literacy before and after implementing a structured learning model. The results indicated a statistically significant increase in overall digital literacy following the intervention. This improvement was evident across all digital literacy components, with the greatest gain observed in Awareness Skills followed by Thinking Skills, Cooperation Skills, and lastly, Sequential Implementation Skills. In conclusion, the findings from this study and existing research provide strong evidence for the effectiveness of the flipped instructional model in enhancing digital literacy skills. The model's structured approach, incorporating elements of flipped classroom pedagogy, demonstrably influences students' learning behaviors and contributes to improved academic achievement.

Table 4. Illustrates the application of Bloom's taxonomy within the instructional model based on flipped using technology-based learning designed to promote digital literacy development among undergraduate students in the Faculty of Education at Rajabhat University

Bloom's taxonomy	**Flipped classroom**	**Pattern procedures**	**Educational technology**	**Pattern of digital literacy**
1. Remembering 2. Understanding	1. Online Out-of-Class Learning	1. Knowledge Acquisition 2. Engagement with Technological Media and Educational Resources 3) Critical Reflection and Question Formulation	Google Classroom, Youtube, Padlet, Quizlet	1. Fundamental digital and informational literacy 2. Access 3. Management
3. Applying 4. Analyzing 5. Evaluating 6. Creating	2. Classroom Instruction	4) Collaborative Knowledge Construction 5) Knowledge Application and Skill Development 6) Assessment and Evaluation	Google Jamboard, Kahoot, Quizizz, Facebook, Google doc, Google Slide, Canva, kinemaster, OBS Studio, Microsoft Word, Microsoft PowerPoint, Poll Everywhere	4. Integration 5. Communication 6. Ingenuity 7. Awareness 8. Evaluation

The research implications for students with varying levels of digital literacy

To serve the students with varying levels of digital literacy, a pretest of digital literacy should be carried out. After that remedial activities are taken place to promote the students' digital literacy to help adjust the students' digital skills to be not too much different, if not at the same level (Puniatmaja, et al., 2023). The remedial activities should be done by the instructor himself or by the 'peers helping peers' approach. This means encouraging the students who are more skillful in digital literacy to assist those who are weaker. After that

objectives and steps of learning methods and activities of flipped learning are explained thoroughly. For the students who are very keen on digital literacy, the instructor should give them more difficult and complex assignments or let them choose a topic of interest of their own to produce piecework (Quraishi, et al., 2024). Besides, the instructor should pay more attention to the weaker digital literacy students to give them extra assistance or encourage their classmates to help them.

Potential modifications of the study to accommodate diverse learning needs

This study is possibly to accommodate diverse learning needs that are compatible with contents and necessary learning skills such as critical thinking, active learning, reflective learning, collaborative learning, and learning community (Pan, 2024). Additionally, the research is appropriate to be employed in training and developing teaching skills of educators for enhancing their digital skills especially how to effectively use and select appropriate modern tools such as search engines and applications that serve learning objectives for their students (Soufiane, et al., 2024). In case learning settings are different the change of setting should be avoided while using the flipped learning model to prevent an effect on the result of the model. The difference in learning settings possibly leads to different results. Strictly following the suggested stages of the developed model will result in an accurate comparison.

5. Conclusion

This study investigated the efficacy of the instructional model based on flipped using technology-based learning in enhancing digital literacy among undergraduate students in the Faculty of Education at Rajabhat University. The findings revealed that this pedagogical approach effectively fostered students' digital literacy skills. Digital literacy is recognized as a critical competency for navigating technological challenges encountered in both professional and personal settings. It encompasses the ability to leverage technology for problem-solving in complex tasks, including information discernment, evaluation, and its application to address issues. Notably, Thailand's National Policy and Plan on Digital Development for the National Economy and Society (2018-2037) emphasizes Strategy 5, which focuses on developing a workforce prepared to thrive in the digital economy and society. However, the implementation of flipped learning necessitates careful consideration by educators regarding the selection of educational technologies for content creation and dissemination. Utilizing online learning platforms, applications, and modern websites can significantly enhance teaching efficiency in this context.

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Authors contributions

Wachira Morachat, the researcher, launched the research project, collected and analyzed the data, and drafted the manuscript. Associate Professor Dr. Thapanee Seechaliao supervised the research project, edited and revised the final manuscript.

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