Development of Flexible Digital Learning Environment Model to Promote Information and Communication Technology Skills

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***Abstract*—This study aimed to develop a Flexible Digital Learning Environment model to enhance Information and Communication Technology (ICT) skills in higher education. The model emphasizes the importance of a well-equipped and engaging learning environment that supports both independent and collaborative learning. Key components of the model include integrating technology, communication, and active learning strategies. Expert evaluations confirmed the model's effectiveness in improving ICT skills. This research offers a practical framework for implementing flexible digital learning environments, contributing to better educational outcomes.**

***Keywords*—flexible digital learning, digital learning environment, information and communication technology skills**

I. Introduction

The COVID-19 pandemic resulted in a global educational crisis, making classroom teaching impossible and necessitating alternative learning methods to ensure continuity in education. Consequently, the United Nations Educational, Scientific and Cultural Organization (UNESCO) established policies to promote the capacity of Education for Sustainable Development (ESD), aiming to increase participation in education and holistic educational development [1]. Long-term higher education developmental guidelines have been established, covering all aspects of educational quality development, including the use of digital technology in classroom practices, management, learning procedures, techniques, as well as assessment and evaluation. These guidelines emphasize the crucial role of the learning environment in facilitating effective educational outcomes [2].

In Thailand, post-COVID-19 education has faced challenges such as limitations in online learning platforms, insufficient teacher training, lack of preparedness in online teaching, poor or inadequate technological infrastructure, and insufficient facilities and resources [3]. These issues pose significant difficulties but also act as catalysts for change, driving the integration of technology into Thailand's educational system. It is crucial for educational administrators to understand and adapt to these changes to enhance the effectiveness of student learning, create conducive learning environments, and develop digital learning management. This shift marks a departure from traditional learning methods towards those leveraging advanced technology, aiming to make teaching and learning more efficient. As a result, students are expected to achieve learning outcomes aligned with educational objectives using various teaching methods [4].

Given the rapid technological advancements, new learning management approaches must be cultivated to enhance teaching and learning quality. This includes developing technology, communication, and information transfer skills, as well as creating conducive learning environments that promote continuous learning using digital tools. Such environments should not only focus on physical aspects but also involve building positive relationships between learners and teachers, fostering teamwork, and effectively developing learners' skills.

This study aims to investigate the flexible digital learning environment to enhance information and communication technology skills and to develop a flexible digital learning environment model to promote these skills. The goal is to provide guidelines for flexible digital learning management tailored to learners' needs, facilitating educational changes with maximum efficiency and effectiveness for the nation [5–8].

II. Literature Review

The development of the flexible digital learning environment model, aimed at promoting information and communication technology skills, was conducted within the framework of Instructional System Design concepts. A digital learning environment, serving as a virtual space designed to support teaching and enhance learning experiences, leverages innovative instructional methods and educational technology advancements. This environment facilitates classroom activities by enabling capabilities such as accessibility, management, collection, communication, and appropriate information dissemination.

A. Strengths and Challenges of Digital Learning Environments

Key strengths of digital learning environments include the ability to learn without constraints of time and place, flexibility in learning methods, adaptation of learning content to suit various situations, use of technology to create engaging experiences, and the ability to monitor and measure progress to enhance learning efficiency. However, these environments also face significant challenges, such as concerns about the quality of learning, lack of immediate assistance for technical issues, and difficulties in establishing strong relationships between learners and instructors. Addressing these challenges is crucial for maximizing the effectiveness and efficiency of

digital education.

B. Active Learning Theories

Active learning theories emphasize student engagement through activities that promote analysis, synthesis, and evaluation. These theories enhance student engagement and promote higher-order thinking skills, which are essential for developing ICT competencies. However, active learning may require more preparation time and can be challenging to implement in large classes. The ETCL Flexible Model includes scalable active learning strategies that can be adapted for different class sizes, ensuring broad applicability and effective engagement. Active learning's focus on student engagement and critical thinking directly contributes to the development of the ETCL Flexible Model by ensuring that learners are actively involved in their learning processes, thereby enhancing their ICT skills.

C. TPACK and ADDIE Models

Incorporating the TPACK Model (Technological Pedagogical Content Knowledge) and the ADDIE Approach (Analysis, Design, Development, Implementation, Evaluation) contributes to creating more effective tools and resources. TPACK integrates technology, pedagogy, and content knowledge to enhance teaching effectiveness. This framework provides a comprehensive approach ensuring balanced integration of technology with pedagogy and content, which is crucial for developing effective digital learning tools. However, implementing TPACK can be complex and requires extensive training for educators. Using the TPACK Model ensures a balanced integration of technology with pedagogy and content, which improves teaching efficacy and is essential for creating digital learning resources that are useful for this research.

The ADDIE Approach is another key framework guiding the systematic development of instructional design. Its strengths lie in offering a structured and iterative approach, ensuring thorough planning and evaluation. However, it can be time-consuming and may lack flexibility if strictly adhered to. The ETCL Flexible Model incorporates flexibility within the ADDIE framework to adapt to changing educational needs and contexts, ensuring a more dynamic approach.

D. Hybrid Learning

Hybrid learning, a blended approach combining face-to-face instruction with online methodologies, offers flexibility and can cater to diverse learning styles. While hybrid learning provides these benefits, it also requires reliable technology infrastructure and can create disparities if access is unequal. Hybrid learning's flexibility and accommodation of different learning styles contribute to the model by providing a balanced approach that leverages both traditional and digital learning methods to enhance student engagement and learning outcomes. The ETCL Flexible Model ensures equitable access to technology and includes support mechanisms for students with limited access, addressing potential disparities and promoting inclusive learning environments.

E. Flexible Learning Management Model

The Flexible Learning Management Model provides knowledge-building activities without constraints on time, place, content, methods, resources, or assessment. It promotes learner autonomy and accommodates individual learning preferences. However, it requires a high level of self-responsibility from learners and may lead to reduced interaction [9]. The ETCL Flexible Model addresses these limitations by including structured support and scaffolding to help learners manage their responsibilities and maintain interaction, thus enhancing engagement and ensuring effective learning. This model's focus on learner autonomy and flexibility directly contributes to the ETCL Flexible Model by enabling personalized learning experiences that cater to individual learner needs and preferences.

F. Edgar Dale's Cone of Learning

Edgar Dale's Cone of Learning illustrates the broadening and deepening of learning through active participation [10]. This concept shows the broadening and deepening of learning through activities like reading, listening, observing, exchanging knowledge, and practice, from passive to active participation. This concept highlights the importance of active engagement for retention and application, but it can be difficult to measure and apply uniformly across different subjects. The ETCL Flexible Model uses a variety of active learning techniques tailored to different content areas to ensure effective application and enhance learning experiences. By incorporating Dale's Cone of Learning, the model emphasizes active learning, which is crucial for retaining information and applying knowledge effectively.

G. Technological Literacy

Technological literacy is essential for learners to adapt to advancements and benefit from them. There are three ways of learning involving technology: about technology, using technology, and with technology. Managing learning with technology promotes knowledge in information, media, and communication, allowing learners to access, manage, integrate, evaluate, and create within a suitable learning environment [11]. Technological literacy's emphasis on understanding and using technology effectively contributes to the ETCL Flexible Model by ensuring that learners can navigate and leverage digital tools to enhance their learning experiences.

H. Digital Communication, Learning Resources, and Assessment

The digital environment enhances educational experiences through technological advancements and innovative teaching methods. It includes components such as Digital Communication, Digital Learning Resources, and Digital Assessment [8, 12]. Hybrid Learning, a blended approach that combines face-to-face instruction with online methodologies, aims to blend suitable learning strategies for efficient content delivery. Although closely related to flexible learning, Hybrid Learning may differ in both time and learning methods [13, 14]. The inclusion of these components ensures that the ETCL Flexible Model provides comprehensive digital learning experiences that enhance communication, resource access, and assessment methods, thereby improving overall learning effectiveness.

I. Flexible Learning Management

The Flexible Learning Management Model provides knowledge-building activities without the constraints of time, place, content, learning methods, resources, or assessment. It allows learners to access knowledge freely and focuses on their potential, promoting their knowledge, abilities, and responsibility. This model benefits teachers by allowing them to adjust teaching methods in real-time, helping learners achieve across three domains: cognitive (knowledge, critical thinking, problem-solving), psychomotor (skill performance), and affective (attitudes, interests). An appropriate environment facilitates these behavior changes [15, 16]. Components of flexible teaching and learning management include synchronous in-person, synchronous online, and asynchronous online methods [17]. This flexibility responds to individual differences, allowing systematic tracking of progress via platforms like Moodle and supporting self-paced learning [18–20]. The focus on flexible learning management enhances the ETCL Flexible Model by providing a versatile and adaptive approach to teaching and learning, ensuring that it can meet the diverse needs of learners effectively.

While existing models and frameworks such as TPACK, ADDIE, Active Learning, Hybrid Learning, and the Cone of Learning provide valuable insights and strategies for developing digital learning environments, each has its limitations. The Flexible Digital Learning Environment Model (ETCL Flexible Model) developed in this study builds upon these strengths and addresses their weaknesses by incorporating flexibility, scalability, and support mechanisms to enhance ICT skills effectively. By integrating structured instructional design with active and hybrid learning strategies, the ETCL Flexible Model offers a comprehensive approach to digital education tailored to diverse learners' needs.

III. Materials and Methods

A. Research Instruments

The research instruments used in this study were carefully designed to ensure validity and reliability. In Phase 1, two online questionnaires were developed:

1) Expectations of the Flexible Digital Learning Environment: Investigated the expectations of both lecturers and students regarding the physical, psychological, and social environments in promoting ICT skills.
2) Requirements for a Flexible Digital Learning Environment: Examined the specific requirements needed to enhance ICT skills through flexible learning environments.

The IOC (Index of Item Objective Congruence) was at 0.67 for both questionnaires. The confidence coefficient, using Cronbach's alpha, was 0.975 for lecturers and 0.979 for students, indicating high reliability.

In designing the questionnaire for this study, the researchers drew inspiration from seminal works by [21, 22]. who have extensively explored the integration of ICT skills in higher education through innovative web-based and reflective video models, respectively. Both studies provided valuable insights into the structuring of questions that effectively measure ICT literacy and integration capabilities among students and educators. These studies underscored the importance of neutral question phrasing to avoid bias in responses, particularly when assessing subjective educational experiences and technological competencies. This methodological choice is pivotal in developing an inclusive and effective digital learning model that genuinely represents diverse student and faculty needs.

For Phase 2, the research instruments included:

1) Appropriateness Evaluation Form: Evaluated components of the flexible digital learning environment model for promoting ICT skills.
2) Semi-Structured Interview Guide: Focused on the effectiveness of the flexible digital learning environment model in promoting ICT skills.

The IOC for both research instruments in Phase 2 was 1.00. Data from these instruments were analyzed using Mean, Standard Deviation (S.D.), and Content Analysis.

B. Research Participants/Respondents

The study involved two groups of participants:

1) Lecturers: 234 lecturers from higher educational levels teaching practical subjects in the fields of Digital Media Technology and Mass Communication, Information Technology and Digital Innovation, Educational Technology, and related fields from 27 higher educational institutes in Bangkok and nearby areas. The sample size was calculated based on Krejcie & Morgan, with the population proportion estimated at 0.5, the tolerance level at 5%, and the confidence level at 95%.
2) Students: 30 third-year undergraduate students majoring in Digital Technology and Mass Communication at the Faculty of Science and Technology at Rajamangala University of Technology Krungthep, selected through purposive sampling.

In Phase 2, the sample group included five experts in the field of Educational Technology and Communication, who evaluated the model's effectiveness. The experts were award-winning national and international educators, providing high-level expertise for the evaluation.

C. Methodology

The study followed a systematic instructional design approach known as the ADDIE Approach, including phases of Analysis, Design, Development, Implementation, and Evaluation. The sample design for this educational research posed certain challenges, which were addressed by employing strategies discussed by Kanaki and Kalogiannakis [23]. The researchers emphasized the importance of careful sample design in educational research to ensure the validity and reliability of the findings.

1) Phase 1—needs assessment

Analysis Phase: A needs analysis was conducted to identify gaps in current digital learning environments. The researchers reviewed literature on digital learning, hybrid learning, and flexible learning models to identify key components and requirements for a flexible digital learning environment tailored to enhancing ICT skills. This phase involved collecting data from 234 lecturers and 30 students using questionnaires and interviews to gather insights on the current

state of digital learning environments and expectations for improvement.

2) Phase 2—model development

1) Design Phase: During this phase, the initial framework of the ETCL Flexible Model was created. It incorporated elements from TPACK, ADDIE, and Active Learning models. A detailed design plan outlining instructional strategies, technology integration, and assessment methods was developed. The design plan was informed by the data collected in the Analysis Phase and aimed to address the identified gaps and leverage the strengths of existing models. Experts in educational technology were consulted to provide feedback on the initial design, which was instrumental in refining the strategies and integration methods.
2) Development Phase: The components of the ETCL Flexible Model, including instructional materials, digital tools, and resources, were developed based on the refined design plan. Questionnaires and interview guides for this phase were created and piloted to ensure they met the identified needs and incorporated feedback from initial trials. This iterative testing and refinement process was crucial for developing effective and practical instructional tools.
3) Initial Implementation Phase: A pilot study was administered with a small group of students and experts to test the practical application of the ETCL Flexible Model. This phase aimed to gather initial feedback on its effectiveness in a real-world setting. The feedback collected was used to make further adjustments and refine the model before proceeding to a more comprehensive evaluation.
4) Evaluation Phase: The effectiveness of the ETCL Flexible Model was evaluated based on the data collected from the implementation phase. This evaluation involved analyzing feedback through both quantitative measures (such as Mean and Standard Deviation) and qualitative methods (such as Content Analysis). The insights gained were critical for finalizing the model, ensuring that it not only met the educational goals but also adhered to high standards of learner engagement and satisfaction.

IV. Ethical Considerations

The study was conducted following the ethical guidelines provided by the Institutional Review Board (IRB) of Srinakharinwirot University. All participants provided informed consent prior to participating in the study. The ethical principles of confidentiality, voluntary participation, and the right to withdraw at any time were strictly adhered to throughout the research process.

The potential impacts of this research on society were carefully considered. This study aims to contribute to the improvement of digital learning environments, which can provide more equitable access to education. The integration of ICT skills in education is crucial for sustainable development and societal progress.

To contextualize potential harm and research misconduct within our study, we refer to the work of Petousi and Sifak [24]. who emphasize the importance of addressing ethical concerns in research to prevent harm and ensure the integrity of scientific work. Their discourse analysis of scientific publications highlights the significance of maintaining ethical standards in research.

V. Result and Discussion

A. Results

The development of the flexible digital learning environment model aimed to promote Information and Communication Technology (ICT) skills by aligning teaching methods with learners' objectives in both theory and practice. This initiative also focused on the effective use of equipment and technological devices to enhance ICT skills and learning outcomes.

The first phase investigated the role of the flexible digital learning environment in promoting ICT skills. The data collected provided insights into the expectations and needs of both lecturers and students, which were then incorporated into the instructional design process.

B. Tables and Figures

Table 1. Expectation of flexible digital learning environment to promote information and communication technology skills—physical environment (n=234)

Item	Mean	S.D.	Level
1. Is the size of your classroom sufficient for the number of learners?	4.37	0.57	high
2. Does the ventilation system in your classroom provide a suitable temperature?	4.04	0.69	high
3. Does the quality of projector system TVs affect your learning?	4.21	0.60	high
4. Does your classroom have a sound system and amplifier that provide clear and loud sounds?	4.46	0.52	high
5. Is the lighting in your classroom adequate and appropriate for learning?	4.47	0.51	high
6. Are the tables and chairs in your classroom moveable, making the space flexible and appropriate for learning?	4.47	0.51	high
7. Is your classroom clean and hygienic with a good, airy atmosphere?	4.47	0.51	high
8. Is your classroom equipped with complete media and teaching equipment?	4.50	0.53	high
9. Are the tools and equipment in your laboratory easily accessible and usable?	4.50	0.53	high
10. Does the application of tools and information technology equipment in teaching promote your ICT skills?	4.46	0.53	high
11. Does the environment outside your classroom impact your learning?	4.35	0.54	high
12. Are there sufficient equipment and tools that allow you to participate in actual practice?	4.56	0.50	highest
13. Are there adequate internet connection points with a stable signal for extensive use?	4.54	0.52	highest
14. Do document or content presentation tools (e.g. Word, PowerPoint) promote your learning?	4.26	0.55	high
15. Do electronic books (e-Book: iBook) promote your presentation skills?	3.85	0.64	high
16. Do online video presentation tools (video media: YouTube) promote your independent learning?	4.34	0.53	high
17. Do brainstorming tools (brainstorm: Padlet, Wooclap) promote collaboration among learners?	4.11	0.64	high
18. Do online meetings (video conference: Zoom Meeting, Microsoft Team) promote your online learning?	4.26	0.55	high
19. Do classroom management systems (learning management system: Moodle, Google	4.43	0.55	high

Item	Mean	S.D.	Level
Classroom, Edmodo) promote your digital learning?			
20. Do online assessment tools (online learning assessment: Kahoot, Plicker) promote your learning activities?	3.89	0.64	high
21. Do online social networks (social media: Facebook, Line) promote communication among learners?	4.30	0.54	high
22. Does learning through Immersive Learning (AR, VR, MR: Spatial) technology promote the integration of your learning?	4.26	0.54	high
Mean	**4.32**	**0.56**	**high**

The results indicate that the physical environment elements received high ratings, with Item 12 ("Are there sufficient equipment and tools that allow you to participate in actual practice?") scoring the highest average of 4.56 with a standard deviation of 0.50. The high mean scores across most items suggest a strong need for well-equipped, technologically advanced, and flexible learning environments. This finding aligns with existing literature emphasizing the role of adequate resources in enhancing learning outcomes. For instance [24]. highlight that sufficient tools and equipment enhance the learning experience by enabling practical, hands-on activities that are essential for mastering ICT skills. This suggests that future learning environments should prioritize the availability and accessibility of high-quality tools and equipment, ensuring that these resources are up-to-date and aligned with current technological standards can significantly improve the effectiveness of ICT education. This data was used to design teaching materials that actively engage learners in hands-on activities.

The lowest mean score (3.85) was for the item regarding electronic books promoting presentation skills, indicating an area that might need further enhancement or support. This might be due to the current format of e-books not being interactive or engaging enough. Future improvements could involve integrating more multimedia-rich content to enhance learner engagement and effectiveness. Incorporating multimedia elements such as videos, interactive exercises, and hyperlinks within e-books could make them more appealing and effective. Additionally, providing training for students and instructors on how to maximize the use of e-books in their learning and teaching processes could further enhance their utility. Studies by Srichan [4]. have shown that multimedia-rich e-books can significantly enhance student learning and engagement.

The results for the psychological environment indicate that Item 1 ("Do you feel that listening to your opinions positively affects your feelings and attitudes?") had the highest average score of 4.55 with a standard deviation of 0.50. This suggests that fostering a supportive and inclusive atmosphere can significantly enhance learners' engagement and satisfaction. This data was used to plan activities that encourage learners to express their opinions and engage in collaborative learning.

Students feeling heard and treated equally likely enhances their motivation and engagement, leading to better learning outcomes. When students feel that their opinions are valued, they are more likely to participate actively in learning activities, collaborate with peers, and take ownership of their learning process. According to findings by Sermsuk and Kamolayabut [25]. a positive psychological environment fosters a sense of community and support, which can significantly boost academic performance and satisfaction.

Table 2. Expectation of flexible digital learning environment to promote information and communication technology skills—psychological environment (n=234)

Item	Mean	S.D.	Level
1. Do you feel that listening to your opinions positively affects your feelings and attitudes?	4.55	0.50	highest
2. Are you able to manage yourself and think creatively and freely?	3.93	0.57	high
3. Does equality between teachers and learners positively affect your relationship with teachers?	4.52	0.53	highest
4. Do too many assignments put stress on you?	3.50	0.66	high
5. Do clear instructions help you plan your studies effectively?	4.45	0.52	high
6. Does close monitoring by teachers make you feel uncomfortable?	3.54	0.61	high
7. Does exchanging knowledge with peers promote your participation?	4.26	0.53	high
8. Do modified activities appropriate for your needs make learning enjoyable and flexible?	4.38	0.52	high
9. Does integrating other subjects help you expand your previous knowledge?	3.87	0.69	high
10. Does practical teaching that does not accommodate all learners result in dissatisfaction for you?	3.62	0.63	high
11. Are there various ways for you to seek advice from teachers?	4.24	0.52	high
12. Does teaching practical subjects make you feel unequal in terms of equipment usage?	3.68	0.65	high
Mean	**4.05**	**0.58**	**high**

However, the lower scores related to stress from assignments and discomfort from close monitoring (means of 3.50 and 3.54, respectively) indicate a need to balance academic demands and support mechanisms better. This could involve offering more flexible assignment schedules or providing additional mental health resources.

To reduce stress from assignments, instructors could consider spreading out deadlines more evenly throughout the semester, providing clear and detailed instructions, and offering support resources such as tutoring or study groups. For reducing discomfort from close monitoring, creating a more trust-based learning environment where students feel empowered to take responsibility for their own learning might help. These approaches are corroborated by Jindanurak [26]. who emphasizes the importance of managing academic stress to improve student well-being and performance.

The results for the social environment reveal that Item 2 ("Do a variety of activities stimulate your learning?") had the highest average score of 4.53 with a standard deviation of 0.52. This suggests that incorporating a variety of learning activities can significantly enhance student engagement and knowledge retention. Peer interaction and varied activities can be further enhanced by incorporating more collaborative projects and interactive learning activities that require teamwork and knowledge sharing. Using technology to facilitate virtual collaboration, such as online discussion forums, group chats, and collaborative software, can also help. Additionally, designing activities that cater to different learning styles and interests can keep students engaged and motivated. This data was used to design diverse activities that

are suitable for learners.

Table 3. Expectation of flexible digital learning environment to promote information and communication technology skills—social environment (*n*=234)

Item	Mean	S.D.	Level
1. Does sharing knowledge with peers promote knowledge exchange among learners?	4.51	0.52	highest
2. Do a variety of activities stimulate your learning?	4.53	0.52	highest
3. Does teamwork create feelings of inequality among learners?	3.83	0.64	high
4. Do options for learning through various media cater to differences among learners?	4.32	0.55	high
5. Do the differences among learners in practical settings have a psychological impact on you?	3.87	0.57	high
6. Does using information technology in teaching and learning enhance your technological potential?	4.31	0.51	high
7. Does cultivating responsibility for shared tools and equipment promote responsible behavior?	4.07	0.58	high
8. Do communication channels with teachers enhance your interaction with them?	4.24	0.51	high
Mean	**4.21**	**0.55**	**high**

The item on teamwork creating feelings of inequality received a lower score of 3.83. This result suggests that respondents generally do not perceive teamwork as causing significant imbalances in collaborative settings. Instead, it indicates that teamwork is not seen as a major challenge in the social environment. This interpretation aligns with [27]. who found that collaborative learning environments tend to reduce perceptions of inequality and promote positive interdependence among students.

1) The summary of findings from Tables 1 to 3 shows that the expectations for a flexible digital learning environment to enhance ICT skills are high across physical, psychological, and social environments. Data was collected from 27 higher education institutes in Bangkok and nearby areas, revealing a mean average of 4.32 (S.D. = 0.56) for the physical environment, 4.05 (S.D. = 0.58) for the psychological environment, and 4.21 (S.D. = 0.55) for the social environment (see Table 4).

Table 4. Summary of expectation of flexible digital learning environment to promote information and communication technology skills (*n*=234)

Item	Mean	S.D.	Level
1. Physical environment	4.32	0.56	high
2. Psychological environment	4.05	0.58	high
3. Social environment	4.21	0.55	high

The results regarding the physical environment requirements indicate that Items 6, 8, and 9 have an average score of 4.80 with a standard deviation of 0.48, ranking at the highest level. This data was utilized in designing and preparing classrooms with adequate equipment to meet the needs of the learners. This is consistent with the findings of [28]. who emphasized that a well-equipped physical environment significantly enhances the effectiveness of digital learning.

The results regarding the psychological environment requirements show that Item 3 ("Is having equality and fairness in class as other learners important to you?") has an average score of 4.77 with a standard deviation of 0.50, ranking at the highest level. These findings are consistent with those of [29]. who argued that equity and fairness in the classroom significantly enhance student engagement and learning outcomes. This data was used to plan teaching strategies that ensure fairness and equality, with no barriers to access or use of equipment.

Table 5. Needs for flexible digital learning environment to promote information and communication technology skills—physical environment (*n*=30)

Item	Mean	S.D.	Level
1. Is a ventilation system that regulates an appropriate temperature in the classroom important to you?	4.67	0.71	highest
2. Is having a projector or TV with sharp images important for your learning?	4.77	0.50	highest
3. Is having a proper sound system and amplifier in the classroom with loud and clear sound important to you?	4.70	0.60	highest
4. Is having adequate and appropriate lighting in the classroom important for your learning?	4.73	0.58	highest
5. Is the ability to move tables and chairs in the classroom important for flexible learning?	4.77	0.50	highest
6. Is having a clean and hygienic classroom with a good, airy atmosphere important to you?	4.80	0.48	highest
7. Are laboratories with tools and equipment that are easily accessible and usable important for your learning?	4.77	0.50	highest
8. Are tools and equipment for participation in practical activities important for your learning?	4.80	0.48	highest
9. Is having a stable and extensive internet connection important for your learning?	4.80	0.48	highest
10. Do document and content presentation tools (e.gWord, PowerPoint) effectively support your learning?	4.57	0.73	highest
11. Do electronic books (e-Books) support your presentations effectively?	4.47	0.78	high
12. Do online video presentation tools (e.g., YouTube) support your independent learning?	4.70	0.60	highest
13. Do brainstorming tools (e.g., Padlet, Wooclap) support collaboration among learners?	4.63	0.61	highest
14. Do online meeting tools (e.g., Zoom, Microsoft Teams) support your online learning?	4.50	0.68	high
15. Do classroom management systems (e.g., Moodle, Google Classroom, Edmodo) support your digital learning?	4.67	0.55	highest
16. Do online assessment tools (e.g., Kahoot, Plicker) support your learning activities?	4.60	0.56	highest
17. Do online social networks (e.g., Facebook, Line) support communication among learners?	4.67	0.55	highest
18. Does learning through immersive technologies (e.g., AR, VR, MR) support the integration of your learning?	4.70	0.53	highest
Mean	**4.68**	**0.58**	**highest**

Table 6. Needs for flexible digital learning environment to promote information and communication technology skills—psychological environment (n=30)

Item	Mean	S.D.	Level
1. Is it important for you to express different thoughts or opinions in class?	4.53	0.63	highest
2. Is the ability to manage and plan your own study freely important to you?	4.60	0.62	highest
3. Is having equality and fairness in class as other learners important to you?	4.77	0.50	highest
4. Is exchanging knowledge with other learners important for your learning?	4.63	0.56	highest
5. Is learning by sharing knowledge with others important for your learning?	4.67	0.55	highest
6. Is receiving attention and care from teachers important to you?	4.70	0.53	highest
Mean	**4.65**	**0.57**	**highest**

Table 7. Needs for flexible digital learning environment to promote information and communication technology skills—social environment (n=30)

Item	Mean	S.D.	Level
1. Is sharing knowledge with peers important for your learning?	4.67	0.55	highest
2. Are a variety of activities important to stimulate your learning?	4.80	0.48	highest
3. Are having options for learning through various media important to you?	4.77	0.50	highest
4. Is using a variety of information technology in teaching and learning important for you?	4.83	0.46	highest
5. Is participating in activities with other learners important for your learning?	4.80	0.48	highest
6. Are different channels for consulting with teachers important to you?	4.73	0.52	highest
Mean	**4.77**	**0.50**	**highest**

The results regarding the social environment requirements indicate that Item 4 ("Is using a variety of information technology in teaching and learning important for you?") has an average score of 4.83 with a standard deviation of 0.46, ranking at the highest level. This is supported by research from [30]. which highlights the importance of social interaction and diverse learning activities in cognitive development with technology tools in classroom. This data was incorporated into organizing diverse activities and providing various media and information technology options to cater to individual differences in learning. based on the findings regarding the learning environment, teachers must integrate teaching methods with various technologies to enable students to learn.

Table 8. Summary of needs for flexible digital learning environment to promote information and communication technology skills (*n*=30)

Item	Mean	S.D.	Level
1. Physical environment	4.68	0.58	highest
2. Psychological environment	4.65	0.57	highest
3. Social environment	4.77	0.50	highest

2) The summary of findings from Tables 5 to 7 indicates that the needs for a flexible digital learning environment to promote ICT skills are at the highest levels across physical, psychological, and social environments. Data was collected from undergraduate students majoring in Digital Media Technology and Mass Communication, revealing a mean average of 4.68 (S.D. = 0.58) for the physical environment, 4.65 (S.D. = 0.57) for the psychological environment, and 4.77 (S.D. = 0.50) for the social environment (Table 8).

From the Phase 1 study, it was found that the physical, psychological, and social environments can promote both teachers and learners by focusing on developing teaching and learning skills appropriate for the specified environments. This can be achieved through training to enhance professional knowledge and skills, creating spaces that support the exchange of ideas between teachers and learners, and offering opportunities for learners to participate in decision-making and planning in their own learning processes. All of these contribute to developing a flexible (draft) format that meets the needs of students, is easily accessible, and safe.

Phase 2: The development of the flexible digital learning environment model

1) The flexible digital learning environment model, or ETCL Flexible Model, was drawn from Phase 1 findings and the synthesis of related concepts. The following Fig. 1 and Fig. 2 present the mode and process of the flexible digital learning environment:

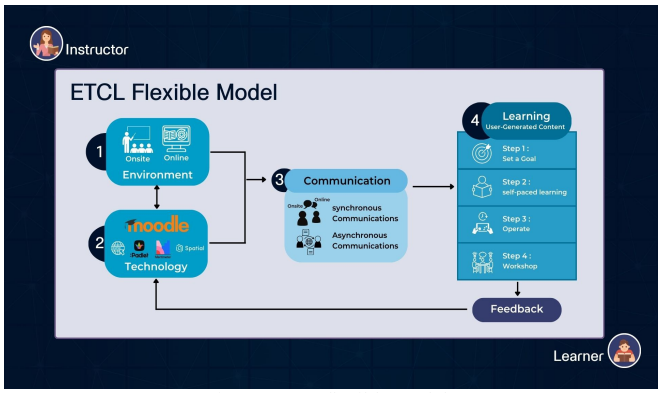

Fig. 1. ETCL flexible model.

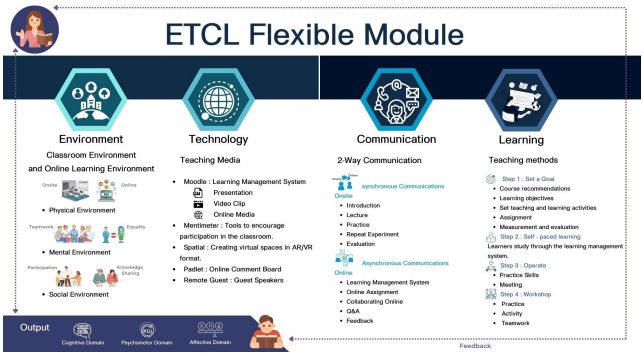

Fig. 2. ETCL flexible module.

The flexible digital learning model consists of four main components:

Environment: Creating a flexible learning environment across all three dimensions: physical, psychological, and social. It aims to provide opportunities and support for learners to fully engage in learning without constraints on time, content, or the use of learning resources. The flexible digital learning environment integrates face-to-face and online learning, fostering interactive and asynchronous learning experiences.

Technology: Creating learning materials that utilize ICT skills, serving as tools or channels that support effective learning. This is achieved through learning management systems, comprising presentation media, video clips, online media, or other applications that promote diverse learning experiences. They are convenient and flexible, adapting to learners' needs. Technology includes a variety of tools such as virtual labs, interactive simulations, and e-learning platforms. These components are designed to overlap where necessary to provide a comprehensive learning experience.

Communication: Involves both synchronous and asynchronous communication. Open learning environments allow learners to interact with instructors or other learners, promoting optimal learning. Communication is separated

from technology to emphasize its critical role in facilitating interaction and collaboration. Tools like discussion forums, chat rooms, and video conferencing are used to enhance communication.

Learning: Managing learning to enable learners to engage in self-directed learning, participate in activities, and create simulated situations for hands-on experience. This allows learners to gain experience and learn from real-world mistakes. This component includes the use of project-based learning, problem-solving exercises, and real-time feedback mechanisms to foster an interactive and engaging learning environment.

These components are related to the learning process, mainly placing an emphasis on the learners, allowing them to be part of the process, and focusing on learning by doing, enabling learners to create a new body of knowledge by themselves. The process consists of four stages:

a) Setting goals and regulations
b) Self-learning from a variety of resources provided by the teachers
c) Practicing
d) Exchanging knowledge with classmates

Practicing enables the learners to participate in the teaching and learning related to ICT. This can be applied to truly develop the learners' practical skills.

2) The aspects of the evaluation regarding the appropriateness of the flexible digital learning environment model to promote ICT skills include Environment, Technology, Communication, and Learning had an IOC range of 0.60 to 1.00. This evaluation result by the experts indicates that the items are congruent and can be effectively used in the context of promoting ICT skills.

Item	IOC	Level
1. Environment	0.60-1.00	Agree
2. Technology	0.80-1.00	Agree
3. Communication	0.60-1.00	Agree
4. Learning	0.60-1.00	Agree
Result	**0.60-1.00**	**Agree**

3) A semi-structured interview was conducted with five experts in educational technology and communication addressing questions regarding instructional design, the steps in developing the model, and the components efficiently promoting a flexible digital learning environment. The findings illustrated five aspects:

a) Designing a flexible digital learning model

The interview findings showed that incorporating digital technology with appropriate flexible learning management systems can help learners access lessons anywhere and at any time. Teachers must provide lessons in which learners can learn in advance and do pre-tests before class. If they fail, they will have to retake the test until they pass, ensuring basic knowledge before actual practice in class. Learners need more alternatives in both synchronous and asynchronous ways; therefore, teachers must find strategies and activities appropriate for each learner. The fifth expert recommended that, "In class, everything must follow the schedule and be punctual as it is synchronous learning. Outside class can be flexible – learners can submit their work at their convenience until deadlines. In other words, on-site learning focuses on skills, while online learning focuses on knowledge acquisition."

b) Application of technology with flexible digital learning

From the semi-structured interview, it can be concluded that flexible digital learning can respond to the learning differences among learners. Regardless of individual learning speeds, platforms like Moodle, a digital technology application, allow learners to learn anywhere at any time. By combining different tools, teaching and learning can be easier and more flexible for learners.

c) Techniques for selecting flexible digital learning media

The interview findings revealed various techniques for selecting flexible digital learning media based on the content being taught:

a) Media for micro-learning: Creating five to six short clips, each preceded by an introduction, before going to the main content. Each clip should ideally be three to four minutes long for quick comprehension and retention.
b) Personal Media: Inviting an expert or a guest speaker to share their experiences.
c) Short Notes: Providing summarized content with charts, diagrams, and additional information to aid self-study.
d) Learning Management System (LMS): Utilizing a program that supports curriculum design, lesson delivery, and collaborative activities. The data is processed systematically for monitoring and assessment.
e) Immersive Media: Creating engaging environments that support self-paced learning.

These media options enable learners to understand lessons and collaborate with others, allowing them to co-create new knowledge. This is an important technique that can be combined with learning media, resulting in flexible digital learning for different content areas.

d) The model of flexible digital learning environment

Based on insights gathered from interviews with the experts, it can be concluded that a flexible digital learning environment should consist of flexibility, mobility, self-paced learning, and collaborative learning. The content and design of such an environment should align with learners' needs. The environment must comprise the following:

a) Online environment: Provides freedom and flexibility for learners to learn at their convenience, meeting their needs for flexibility.
b) On-site environment: Allows learners to experience actual practice, which may not be as flexible as an online environment but is flexible in that learners do not have to study only in class. The focus is on practical experience, allowing faster learning.

In terms of technology, supporting tools to aid instruction, production, and design should be available to facilitate teachers who implement flexible teaching methods. For example, educational institutes abroad, such as the University of Newcastle, utilize platforms such as Blackboard, offering features like attendance checking, academic result tracking, and academic result evaluation. This benefits teachers employing flexible teaching in terms of lesson plans,

innovations, and technology.

e) Guidelines for self-development for teaching and learning for flexible digital learning

The interview indicated that teachers must be aware that learners are very familiar with online learning. Thus, teachers should leverage this familiarity with online platforms to enhance the online learning experience. Additionally, in-class instruction should adopt a flipped classroom approach, enabling learners to study theories before class. This approach can respond to each learner's needs to comprehend classes and review lessons as they wish. The fourth expert stated that incorporating technology into the learning process enables flexible learning to have essential elements such as flexibility, mobility, self-paced learning, and collaborative learning, all of which align with learners' preferences and needs.

The development of the flexible digital learning environment model (ETCL Flexible Model) takes into account several critical factors to ensure its effectiveness and security. In particular, it incorporates findings from studies related to privacy concerns in e-learning [31]. and barriers to successful implementation [32].

Chou and Chen [31]. highlight the importance of protecting personal data and maintaining the confidentiality of learner information. To address these concerns, the ETCL Flexible Model incorporates robust data encryption methods and secure access protocols to safeguard students' personal and academic information. The model ensures that all digital platforms and tools comply with data protection regulations such as GDPR and FERPA. Another critical aspect of privacy is obtaining explicit consent from users before collecting and using their data. The model includes mechanisms for obtaining informed consent and provides learners with control over their data. Learners can access, modify, or delete their data, ensuring transparency and trust in the digital learning environment. The ETCL Flexible Model also considers the need for anonymity in online interactions, as noted by Chou and Chen [31]. To address this, the model incorporates features that allow learners to participate in discussions and activities anonymously if they choose. This encourages open and honest communication while protecting individual privacy.

Quadri *et al.* [32]. identify inadequate technological infrastructure as a significant barrier to e-learning implementation. The ETCL Flexible Model addresses this by ensuring that the necessary technological infrastructure, including high-speed internet access, reliable hardware, and up-to-date software, is in place. The model also advocates for regular maintenance and upgrades to the technological infrastructure to support seamless learning experiences. To overcome barriers related to the lack of technical support, the ETCL Flexible Model includes comprehensive training programs for both instructors and students. These programs cover the use of digital tools, troubleshooting common issues, and best practices for online learning. Additionally, a dedicated technical support team is available to assist users with any technical challenges they may encounter.

Accessibility is another critical barrier highlighted by Quadri *et al.* [32]. The ETCL Flexible Model ensures that all digital learning materials and platforms are accessible to learners with disabilities. This includes the use of screen readers, subtitles for video content, and adaptable interfaces that cater to different learning needs. By promoting inclusivity, the model ensures that all learners have equal opportunities to succeed. The study also points out that traditional teaching methods may not always translate well to an online environment. The ETCL Flexible Model incorporates innovative pedagogical approaches such as flipped classrooms, project-based learning, and interactive simulations to make the learning experience more engaging and effective. By aligning teaching methods with the capabilities of digital platforms, the model enhances the overall learning experience.

In terms of implementation, the ETCL Flexible Model integrates privacy and security measures such as data encryption, role-based access controls, and tools for managing user consent. To overcome technological barriers, it emphasizes infrastructure investment, comprehensive training programs, and accessibility features. Pedagogical innovations such as flipped classrooms, project-based learning, and interactive simulations are also integral to the model. By incorporating these comprehensive measures, the ETCL Flexible Model ensures that privacy concerns are addressed, barriers to implementation are overcome, and the digital learning environment is both effective and secure. This holistic approach not only enhances ICT skills but also promotes a safe and inclusive learning experience for all participants.

VI. Conclusion

The development of the Flexible Digital Learning Environment model, grounded in the theory of knowledge construction through learner-centered learning management, represents a significant advancement in educational technology. The model emphasizes flexibility in time, content, and learning activities, accommodating both onsite and online formats. By aligning with learners' abilities and preferences, it fosters flexible and independent learning. The use of various tools and online communication platforms enhances ICT skills and supports collaborative learning tailored to learners' needs.

Using a teaching model that emphasizes the development of ICT skills offers multiple benefits beyond just mastering technology. It also fosters self-learning, where students are empowered to set their own learning goals, seek out information independently, and evaluate their progress. This model promotes lifelong learning by equipping students with the tools and skills necessary to continuously educate themselves and adapt to new challenges. Consequently, students can sustain their personal and professional growth over time, leading to a more adaptable and capable workforce.

However, this study has several limitations. The small sample size of 30 students from a single course may limit the generalizability of the findings. Additionally, the involvement of only five experts in evaluating the model may not provide a comprehensive assessment. Future research should involve a larger and more diverse sample to validate the model's effectiveness and scalability.

Recommendations for educators include integrating

flexible digital learning environments to enhance learner engagement and personalization. Policymakers should support the development and implementation of such models through funding and resources. Further research should explore the long-term impacts of the model on various educational outcomes and its adaptability across different contexts. Additional studies could refine the model's components to improve its utility and effectiveness.

In the future, an adaptive learning model can be developed that focuses on responding to the needs and behaviors of each user by leveraging AI and gamification. This approach can enhance the learning management system by tailoring lessons, answering questions, and creating teaching media that are customized to each student's learning style and progress. Such a model can facilitate interactive learning activities, making the learning process more engaging and effective, especially in an online format.

Conflict of Interest

The author declares no conflict of interest.

Author Contributions

Naipaporn Jarukasetwit conducted the research, collected and analyzed the data, and was the main author. Khwanying Sriprasertpap, and Naruemon Sirawong were thesis advisors who provided suggestions and guidance on writing this article. All authors had approved the final version.

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