



## UTILIZING DESIGN THINKING TO CREATE DIGITAL SELF-DIRECTED LEARNING ENVIRONMENT FOR ENHANCING DIGITAL LITERACY IN THAI HIGHER EDUCATION

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### ABSTRACT

Aim/Purpose	To explore the effectiveness of utilizing the design thinking approach in developing digital self-directed learning environment to enhance digital literacy skills in Thai higher education.
Background	To foster digital literacy skills in higher education, Thai students require more than access to technology. Emphasizing digital self-directed learning and incorporating Design Thinking approach, can empower students to learn and develop their digital skills effectively. This study explores the impact of digital self-directed learning environment, developed using a design thinking approach, on enhancing digital literacy skills among higher education students in Thailand.
Methodology	The research methodology involves developing a digital self-directed learning environment, collecting and analyzing data, and using statistical analysis to compare the outcomes between different groups. The sample includes 60 undergraduate students from the School of Industrial Education and Technology at King Mongkut Institute of Technology, divided into a control group (n=30) and an experimental group (n=30). Data analysis involves mean, standard deviation, and one-way MANOVA.
Contribution	This research contributes to the evidence supporting the use of Design Thinking in developing digital self-directed learning environment, demonstrating its effectiveness in meeting learners' needs and improving learning outcomes in higher education.

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Findings	Key findings include the following: 1) the digital media and self-directed learning activities plan developed through the design thinking approach received high-quality ratings from experts, with mean scores of 4.87 and 4.93, respectively; and 2) post-lesson comparisons of learning outcome and digital literacy assessment scores revealed that the group utilizing digital media with self-directed learning activities had significantly higher mean scores than the traditional learning group, with a significance level of 0.001.
Recommendations for Practitioners	Practitioners in higher education should use design thinking to develop digital self-directed learning environments that enhance digital literacy skills. This approach involves creating high-quality digital media and activities, promoting engagement and improved outcomes. Collaboration and stakeholder involvement are essential for effective implementation.
Recommendations for Researchers	Researchers should continue to explore the effectiveness of design thinking approaches in the development of learning environments, as well as their influence on different educational aspects such as student engagement, satisfaction, and overall learning outcomes.
Impact on Society	By enhancing digital literacy skills among higher education students, this study contributes to the development of a digitally skilled workforce, encourages life-long learning, and aids individuals in effectively navigating the challenges of the digital era.
Future Research	Future research could explore a broader range of student demographics and educational settings to validate the effectiveness of the Design Thinking approach in enhancing digital literacy. This could include integrating design thinking with alternative digital learning and teaching methods to further improve digital literacy.
Keywords	design thinking, digital self-directed learning, digital media, digital literacy

## INTRODUCTION

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Digital literacy skills are essential in today's world as technology continues to shape various aspects of our lives. In Thailand, the number of internet users has been growing steadily, with an estimated 55 million users as of February 2023 (Kemp, 2023). This rapid growth emphasizes the importance of digital literacy in higher education, where technology plays a significant role in learning and communication. Jisc (2014) highlights that students need digital literacy skills to successfully navigate and thrive in this constantly evolving digital environment. Therefore, fostering the development of digital literacy skills in higher education is crucial for preparing students to engage with the digital world confidently and effectively. Baharuddin (2016) highlights challenges faced by undergraduates due to inadequate digital literacy skills, emphasizing the need to enhance digital literacy in higher education. Similarly, Srichan et al. (2020), and Techataweewan and Prasertsin (2017) stress the necessity for improved digital literacy skills among students in specific Thai universities. Addressing these gaps in digital literacy is crucial for students to excel academically and professionally, with Anthonysamy (2020) highlighting its significance in enhancing graduate employability in the dynamic digital economy.

While the Thai government recognizes the importance of digital literacy skills, the development of these skills in higher education requires more than just access to digital technology. Students need to learn how to use digital tools independently. Digital self-directed learning is one approach that can help students learn digital literacy skills independently. Furthermore, incorporating the Design Thinking approach into the creation of digital media for use in digital self-directed learning can facilitate

the development of digital literacy skills among higher education students. Design thinking is a problem-solving approach that emphasizes creativity, innovation, and human-centered design. It involves a collaborative and iterative process that seeks to understand users' needs, identify opportunities, prototype solutions, and test and refine ideas (Brown, 2008).

This research aims to explore the effectiveness of utilizing the design thinking approach in developing digital self-directed learning environment to enhance digital literacy skills in Thai higher education. The findings of this study are expected to contribute to the promotion of learning methods tailored to improve learners' digital literacy. Research Questions are twofold: 1) How can a digital self-directed learning environment (comprising digital media and a learning activities plan) be created to promote digital literacy skills among higher education students through the design thinking approach? 2) What are the differences in learning efficiency between the digital self-directed learning group and the traditional learning group among higher education students?

### ***DIGITAL LITERACY***

Digital literacy is an essential skill set in the 21st century, empowering students to excel academically and adapt to the ever-changing digital landscape. Digital literacy encompasses various skills, including finding, evaluating, creating, and communicating information using digital technology. Challenges in higher education digital literacy include inadequate skill levels, lack of standardized curricula, and insufficient infrastructure (Blue, 2022; UNICEF, n.d.). Tejedor et al. (2020) highlights the importance of digital literacy for modern education. The study compares adaptations in Spain, Italy, and Ecuador during the COVID-19 lockdown to promote digital literacy. A quantitative study with a customized questionnaire on 376 students highlights the need for enhanced teacher skills, adaptable learning sources, effective communication, and updated teaching methods. The research emphasizes the urgency of rethinking higher education to prioritize communication, teaching strategies, and digital competences, ensuring digital literacy. In the United Kingdom, although the significance of digital literacy to employers across sectors is evident, notable gaps persist. The role of educational institutions in fostering advanced digital literacy has grown increasingly crucial. It's vital to emphasize both the recognized importance of digital literacy among employers and the imperative for improvement. Universities must play a central role in cultivating the next generation of highly skilled, adaptable, innovative, and digitally literate graduates entering the workforce (The Consultancy, 2021). Similarly, the educational development in Thailand should prioritize equipping students with both digital and financial literacy, enabling them to effectively deal with global transformations and establish resilience against future uncertainties (Arunmas & Chantanusornsiri, 2022). However, concerning digital literacy, Thai higher education studies reveal students' high communication skills but moderate proficiency in other digital literacy areas, emphasizing the need for improved skill development in curricula (Tuamsuk, 2017; Ussarn et al., 2022). To enhance digital literacy in Thai higher education, encouraging digital self-directed learning presents a promising approach (Rini et al., 2022).

In this research, the author has employed the digital literacy framework proposed by Sriwisathiyakun and Dhamanitayakul (2022) to develop digital media, specifically online videos, for digital self-directed learning. The framework comprises four components: Access, Analyze & Evaluate, Create, and Reflect & Act. These components emphasize their importance in nurturing digital literacy skills among higher education students. Access pertains to the ability to access information and communication safely using digital technology, while Analyze & Evaluate involves the ability to analyze, evaluate, and assess information and digital media. Create refers to the capacity to produce digital content and information and Reflect & Act relates to the ability to apply and implement changes.

### ***DIGITAL SELF-DIRECTED LEARNING***

Self-directed learning (SDL) is an approach where learners take control of their own learning process, setting goals, selecting learning strategies, and evaluating their progress (Knowles, 1975). SDL is con-

sidered a crucial skill for students in higher education, as it promotes lifelong learning, critical thinking, and adaptability in a constantly changing world. The ability to learn on one's own has become necessary in the 21st century, and higher education institutions have recognized the importance of SDL by making it a part of their curriculum. SDL involves students' self-assessment of learning needs, independent identification and analysis of relevant information, and credibility appraisal of information sources. It is important for higher education to provide learning environments that facilitate the growth and maintenance of SDL (du Toit-Brits, 2020; Giddings, 2014; Weill Cornell Medical College-Qatar, 2014). Digital self-directed learning (DSDL) is an extension of SDL that incorporates digital technologies, tools, and resources. SDL in the digital context is linked to learning motivation and achievement and has been explored in recent studies (Liu., 2022). Teachers can support SDL by directing students to relevant online resources. Briggs and Sherman (2018) suggest that students can benefit from self-directed and individualized approaches to language learning facilitated by digital resources. Digital media, including websites, blogs, podcasts, videos, e-books, and social networks, serves as the primary means through which self-directed learning takes place in the digital domain, providing learners with easy access to a wealth of information and resources, allowing them to explore diverse topics and materials according to their interests and goals.

In this study, the researcher has utilized a teaching approach that emphasizes the learning process of students by shifting the role of teachers from controllers of the learning process to facilitators of self-directed learning (Silamut & Sovajassatakul, 2021). The approach consists of: 1) Readiness Triggers: Stimulating students' preparedness for learning. 2) Setting Goals and Planning: Encouraging students to establish their learning objectives and devise plans to achieve them. 3) Learning Activities: Engaging students in various activities that promote self-directed learning. 4) Learning Evaluation: Assessing students' learning outcomes and progress in self-directed learning.

### *DESIGN THINKING*

Design thinking is a human-centered problem-solving approach consisting of five stages: empathize, define, ideate, prototype, and test. The empathize stage involves understanding users' needs and motivations, while the define stage focuses on identifying the problem to be solved. The ideate stage is concerned with generating ideas, the prototype stage deals with creating a tangible representation of the idea, and the test stage consists of testing the prototype with users. Design thinking has been recommended as a means of developing innovative teaching and learning approaches that are interdisciplinary, experiential, and student-centered (Hasso Plattner Institute of Design, n.d.). In the context of digital self-directed learning (DSDL), design thinking can guide the development of digital learning resources and tools tailored to learners' needs and preferences. A study by Ní Shé et al. (2021) investigated the use of design thinking in the development of the fully online #OpenTeach course. The study found that integrating the five iterative stages of design thinking into the course design and development process allowed for empathy with learners and successful engagement with learning objectives. Design thinking is proposed as an effective methodology for ensuring that the needs of online students are being met in instructional design. Furthermore, Design thinking has been employed in various fields to create user-centered solutions. Marko-Holguin et al. (2019) developed a two-way interactive SMS tool for patients with chronic medical conditions, enhancing patient engagement and addressing complex healthcare needs. Puebla et al. (2022) utilized design thinking to create a language learning app for older adults, resulting in a well-received prototype with high usability scores. Matsui (2023) applied design thinking to reform a university's Japanese language course curriculum, leading to a personalized flipped learning curriculum, while also revealing limitations in the approach. Pereira and Russo (2018) conducted a systematic literature review on the integration of design thinking in agile software development, demonstrating improved understanding of customer needs and increased software quality and usability.

In conclusion, enhancing digital literacy skills in higher education is critical for students to thrive in the 21st century. By promoting digital self-directed learning and leveraging design thinking approach,

educators can develop innovative teaching strategies and digital learning resources tailored to learners' needs and preferences.

## RESEARCH METHODOLOGY

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### *RESEARCH DESIGN*

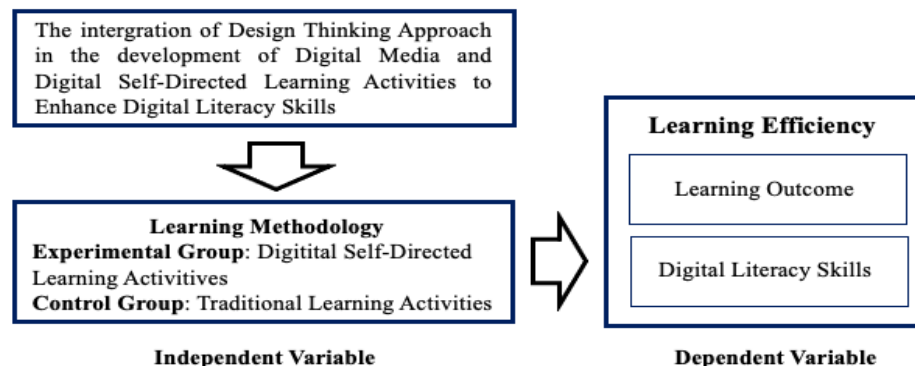
This study employed a mixed-methods research design to comprehensively explore the impact of a digital self-directed learning environment developed using a design thinking approach on enhancing digital literacy skills among higher education students. The study consists of two main phases: (1) the development of the digital self-directed learning environment; and, (2) a comparative analysis between the digital self-directed learning group and the traditional learning group.

### *PARTICIPANTS*

**Population:** The study population comprises 330 undergraduate students enrolled in the Digital Media and Technology for Learning course at the School of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, during the second semester of 2022.

**Sample:** Using a purposive sampling method, a sample of 60 undergraduate students from the same faculty and course was selected for the second semester of 2022. These students were divided into two distinct study groups:

1. **Experimental Group (Group 1):** This group, consisting of 30 students, participated in digital self-directed learning activities using the developed digital media.
2. **Control Group (Group 2):** This group, also comprising 30 students, engaged in traditional learning activities.



**Figure 1: Research Framework**

The research framework, illustrated in Figure 1, consists of the following components:

1. **Independent Variable:** The study's independent variable is the type of learning activities, categorized into two groups: digital self-directed learning activities utilizing digital media, and traditional learning activities.
2. **Dependent Variables:** The dependent variables investigated in this research include students' learning outcomes and their digital literacy skills.

## PROTECTION OF PARTICIPANTS' RIGHTS

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The researcher considered the protection of participants' rights by obtaining permission to collect research data from the Chair of the Human Research Ethics Committee at King Mongkut's Institute of Technology Ladkrabang. The research was granted approval with the certification number EC-KMITL\_65\_106, effective from September 2, 2022. The researcher explained the study's purpose

and data collection procedures to the participants before gathering research data. Additionally, the participants were informed that their names would not be disclosed, and the research findings would be kept confidential and used for academic purposes only.

## RESEARCH PROCEDURES

The researcher employed the Design Thinking framework developed by the Hasso Plattner Institute of Design at Stanford, also known as Stanford d.school (n.d.). The framework consists of the following five steps as shown in Figure 2.

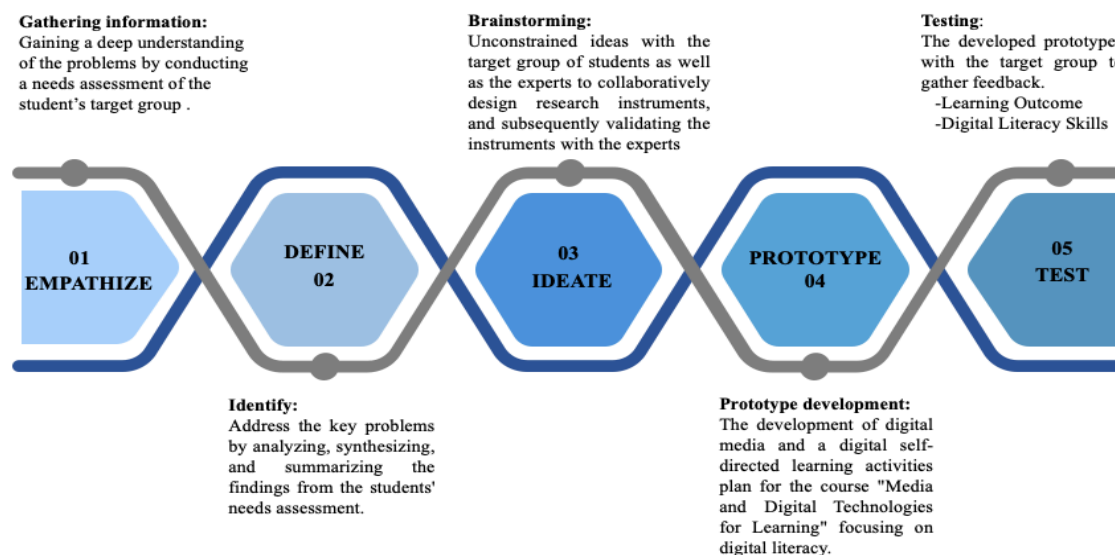


Figure 2: The five-steps Design Thinking framework, applied in the research procedures

### *EMPATHIZE*

This step involves collecting information and gaining a thorough understanding of the challenges faced by the target group of students to develop digital self-directed learning environment, which consist of learning activities and digital media, in the form of online videos. During this stage, the researcher conducted a needs assessment for the learners, focusing on three dimensions: the current state of digital media usage in learning, the patterns of digital media usage, and the learners' knowledge and understanding of digital literacy.

### *DEFINE*

This step involves analyzing, synthesizing, and summarizing the problem points from the findings gathered during the Empathize stage to effectively design and develop digital self-directed learning that effectively promotes digital literacy skills according to the learners' needs. It was concluded that learners desired self-directed learning experiences in an online digital environment and had a strong preference for the development of digital video media formats. Furthermore, they wished to apply digital tools to create positive changes in their daily lives. Therefore, the researcher focused on designing content that emphasized the application of digital tools to create transformative changes, particularly in designing digital video content on digital literacy, to maximize the application of these skills in everyday life.

### *IDEATE*

Based on the results from the previous two steps, this stage involved brainstorming unconstrained ideas to generate novel solutions to address problems in a practical manner. The researcher brainstormed with the target group of learners as well as the three experts, including an educational technology specialist, a curriculum and instruction expert, and an information technology specialist to collaboratively design relevant research tools, which included:

- A three-week digital self-directed learning plan consisting of learning activities for the course on “Media and Digital Technologies for Learning”. This plan covers Unit 1: Media Literacy, and Unit 2: Digital Literacy, with a predetermined schedule and learning activities spanning three weeks.
- Digital media resources, including five video topics: 1) Creating secure usernames and passwords, 2) Safe usage of mobile banking, 3) Methods for verifying fake news, 4) Secure online shopping, and 5) Utilizing Google Maps.
- The quality assessment tools for learning activity plans and digital media evaluation were designed as 5-point rating scales for expert review to assess quality.
- Achievement Test: The achievement test is a post-unit assessment for students who have participated in learning activities developed for each unit. The test measures learning achievement by calculating the average score of students, which reflects their knowledge and abilities acquired. The test is a multiple-choice format with 4 options and 40 questions in total.
- Learner’s Digital Literacy Skills Assessment: A 5-point rating scale consisting of a question set for assessing skills in 4 areas: 1) Accessing, communicating, and safely using digital technology (Access); 2) Analyzing, evaluating, and assessing information and digital media (Analyze and Evaluate); 3) Creating content and information (Create); 4) Applying and implementing change (Reflect & Act). Students assess themselves (Self-Assessment) with 20 questions in total.

The achievement test and digital literacy skills assessment were reviewed by experts to ensure the accuracy and validity of the evaluation tools using the Index of Item Objective Congruence (IOC) method. After the experts had reviewed and provided their feedback, the researcher made appropriate adjustments according to their recommendations before testing the assessments with a sample group in the subsequent stage.

### *PROTOTYPE DEVELOPMENT*

In this phase, the researcher developed prototypes based on the designs as follows:

- Development of digital media, including five sets of videos and other related materials, which are stored on an online platform (Youtube.com) and accessible to learners through the internet.
- A digital self-directed learning plan using digital media for the course “Media and Digital Technologies for Learning”, focusing on digital literacy. The researcher developed a timeline and learning activities spanning three weeks.

Additionally, the prototypes will be evaluated for quality by three additional experts in the fields of educational technology, curriculum and instruction, and information technology. Following this evaluation, the prototypes will be tested in the subsequent testing phase.

**Table 1: Experimental design**

Sample groups	Pre-test	Treatment	Post-test
RE	-	X	O <sub>1</sub> O <sub>3</sub>
RC	-	-	O <sub>2</sub> O <sub>4</sub>

**RE** represents the experimental group, which learns through digital self-directed learning activities with digital media.

**RC** represents the control group, which learns through traditional learning methods.

**X** represents the engagement in digital self-directed learning activities with digital media.

**O<sub>1</sub>** represents the test results of the learning outcomes for the experimental group.

**O<sub>2</sub>** represents the test results of the learning outcomes for the control group.

**O<sub>3</sub>** represents the digital literacy skills of the experimental group.

**O<sub>4</sub>** represents the digital literacy skills of the control group.

## TESTING

This phase involved testing the developed prototypes with the target group to gather feedback. The researcher designed the experiment as shown in Table 1.

## DATA ANALYSIS

The quality of the learning activity plan and digital media were evaluated by experts through the analysis of mean ( $\bar{X}$ ) and standard deviation (S.D.) of expert opinions. The interpretation of the mean value is divided into five levels as follows:

Mean value 4.50 - 5.00: Excellent quality

Mean value 3.50 - 4.59: Good quality

Mean value 2.50 - 3.49: Moderate quality

Mean value 1.50 - 2.49: Fair quality

Mean value 1.00 - 1.49: Needs improvement

The quality acceptance criterion requires a mean value of 3.50 or higher in each aspect, which means that each aspect must be at least at a good quality level.

The learning outcomes and digital literacy skill levels of learners participating in digital self-directed learning activities with digital media (experimental group), compared to learners in traditional learning settings (control group), were analyzed and compared using one-way MANOVA statistical analysis, mean values, and standard deviations.

## RESULTS

### THE QUALITY OF DIGITAL MEDIA

The prototype of digital media for digital self-directed learning activities to promote digital literacy skills has been developed into five video sets and published on the YouTube platform. The quality of the videos was assessed by three experts before being implemented in the digital self-directed learning process. The study results are presented in Table 2.

**Table 2: Digital media quality opinion analysis**

Assessment categories	Expert opinion level		
	$\bar{X}$	S.D.	Quality level
	Contents development	4.93	0.26
Media development	4.80	0.41	Excellent
Utilizing digital media for beneficial purposes	4.87	0.35	Excellent
Summary	4.87		Excellent



According to Table 2, the data analysis results of expert opinions indicate that the digital media used in self-directed learning activities related to digital literacy demonstrates an excellent quality (mean = 4.87). In terms of content, it is also found to be of excellent quality, providing complete, accurate, and comprehensive information related to the research topic. The presentation of the content is appropriate, with a well-structured sequence and easily understandable language. Additionally, the text and language used for communication are correct, clear, easy to understand, and suitable for learners.

In terms of digital media development, the overall quality is at an excellent level. The digital media is hosted on the youtube.com platform, which is easily accessible. The layout and clarity of its components (image, video, sound, text) are excellent, with the highest average score. The length of the digital media is appropriate for each learning unit, also receiving the highest average score. Additionally, the design and development process of the digital media is appropriate and follows the Design Thinking methodology.

Finally, regarding the utilization of digital media, the overall quality is also excellent. This digital media can be effectively utilized in self-directed learning to support digital literacy and cater to learning in the digital age.

### ***THE DEGREE OF CONSENSUS ON THE DIGITAL SELF-DIRECTED LEARNING ACTIVITIES PLAN***

The results of a qualitative study on the effectiveness of a digital self-directed learning activities plan for promoting digital literacy skills among undergraduate students at the School of Industrial Education and Technology, King Mongkut's University of Technology, are presented in Table 3.

**Table 3: The analysis of expert opinions on the learning activities plan**

Assessment Criteria	Expert opinion level		
	$\bar{X}$	S.D.	Quality level
	The learning process is consistent with the learning objectives and content.	5	0.00
The design of learning activities follows the steps of self-directed learning.	5	0.00	Excellent
The digital media used is relevant to the content and learning objectives.	5	0.00	Excellent
The methods of measurement and evaluation are related to the learning objectives, content, and learning activities.	5	0.00	Excellent
The duration of learning activities is consistent with the steps of self-directed learning.	4.67	0.58	Excellent
Summary	4.93		Excellent

According to Table 3, the analysis of expert opinions on the level of agreement indicates that the overall quality of the self-directed digital learning plan for promoting digital literacy skills is of excellent quality (mean = 4.93). Upon examining each aspect, it was found that the plan demonstrates a high level of excellence in every area, including learning steps that align with the learning objectives, the design of learning activities following the self-directed learning process, digital media that are consistent with the content and learning objectives, assessment methods that are relevant to the learning objectives, content, and learning activities, as well as the duration of learning activities that correspond with the self-directed learning process at the highest level of excellence.

**COMPARATIVE STUDY RESULTS OF LEARNING EFFICIENCY**

The researcher tested a prototype with a target group of 30 self-directed learners using digital media and compared the results with a control group of 30 learners to evaluate learning outcomes and digital literacy skills. The results are presented in Tables 4 to 6.

**Table 4: Descriptive**

	Group	Learning Outcome	Digital Literacy Skill
N	Experimental Group	30	30
	Control Group	30	30
Mean	Experimental Group	26.1	4.27
	Control Group	23.1	3.59
Standard deviation	Experimental Group	2.46	0.283
	Control Group	3.88	0.700

**Table 5: Multivariate Test**

		value	F	df1	df2	p
group	Pillai's Trace	0.389	18.1	2	57	< .001
	Wilks' Lambda	0.611	18.1	2	57	< .001
	Hotelling's Trace	0.636	18.1	2	57	< .001
	Roy's Largest Root	0.636	18.1	2	57	< .001

**Table 6: Univariate Test**

	Dependent Variable	Sum of Squares	df	Mean Square	F	p
group	Learning Outcome	138.02	1	138.017	13.1	< .001
	Digital Literacy Skills	6.89	1	6.888	24.1	< .001

Descriptive statistics revealed that the experimental group had higher mean scores for both learning outcomes (Mean=26.13, SD=2.460) and digital literacy skills (Mean=4.27, SD=0.283) compared to the control group (learning outcomes: Mean=23.10, SD=3.881; digital literacy skills: Mean=3.59, SD=0.700).

In this study, the sample sizes are equal across groups, with each group having 30 participants (N = 30). This is a favorable condition, as it demonstrates the robustness of the MANOVA when evaluating differences between two groups. The multivariate tests revealed significant differences between the two groups for all four tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root), with p-values < .001 and F=18.1. Furthermore, univariate tests revealed significant group differences in both learning outcomes (F=13.1, p< .001) and digital literacy skills (F=24.1, p< .001).

## DISCUSSION

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Design thinking is a valuable tool for education. It allows educators to create learning experiences that truly meet the needs of their learners, leading to increased engagement and, ultimately, better learning outcomes (Design Beep, 2023). This research demonstrates how the application of the design thinking approach can facilitate the creation of a digital self-directed learning environment, fostering the development of digital literacy skills among higher education students. The findings of this research confirm that the design thinking approach can be an effective tool for developing digital self-directed learning environment to enhance digital literacy skills among higher education students in Thailand. This assertion harmonizes with the findings of Avsec and Jagiello-Kowalczyk (2021), which suggest that design thinking is strongly connected with self-directed learning. Moreover, the results showed that the digital media and learning activities plan developed through the design thinking process received high-quality ratings from experts and the group utilizing these tools had significantly higher mean scores in both learning outcomes and digital literacy skills compared to the traditional learning group. These findings align with prior research by Taheri et al. (2016), indicating that design thinking in the teaching-learning process aims to increase student happiness, social and psychological satisfaction, and convenience by solving their problems, meeting their needs, and achieving their interests. Furthermore, design thinking is a valuable approach for creating tailored and effective learning experiences in diverse educational contexts, particularly in eLearning courses, where it emphasizes understanding learner needs, objectives, and behaviors and promoting constant stakeholder collaboration and solution fine-tuning throughout the development process (Elwood et al., 2016; Hurix, 2023; Matsui, 2023).

As shown by the MANOVA analysis, the study also revealed a significant difference in learning efficiency between students who learned in a digital self-directed learning environment, developed using design thinking, and those who learned in a traditional classroom setting. Specifically, the experimental group, which is the digital self-directed learning group, demonstrated higher learning efficiency compared to the control group. These findings are in line with the study by Khalid et al. (2020), which shows a significant difference in self-directed learning between online and traditional university students, with a higher correlation to academic success in online self-directed learners. They are also consistent with those of Jin et al. (2022), who developed an online self-directed learning environment (OSDLE) to promote creativity performance and found that students using the OSDLE exhibited significant improvements in creativity performance and self-directed learning capabilities. The results also align with the work of Wen et al. (2022), who developed a learner-centered electronic book (e-book) to promote self-directed learning for medical technologists and found that most readers had positive learning experiences and better learning outcomes. Additionally, the study by Jeong (2022) is in line with our findings, showing that utilizing mobile-assisted learning as a self-directed environment for English study not only enhances learner motivation and makes learning more sustainable and entertaining but also boosts self-efficacy in English learning performance compared to conventional instructional methods. The convergence of these studies with our research further strengthens the validity of our findings.

## CONCLUSION

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This research conducted in the context of Thailand's higher education system underscores the effectiveness of the Design Thinking approach in establishing a digital self-directed learning environment, thereby enhancing students' digital literacy skills. This study contributes significantly to the growing body of evidence supporting the integration of Design Thinking in the creation of digital self-directed learning materials. The application of Design Thinking not only provides a deeper understanding of students' needs but also leads to more engaging learning experiences and improved educational outcomes within Thai higher education. However, it's important to acknowledge the potential bias introduced by the enthusiasm for this approach, which could impact the evaluation of the developed digital learning materials. To mitigate such biases, this research incorporated a control group

and employed rigorous statistical analyses to compare outcomes between the digital self-directed learning group and a traditional learning group. The findings reveal statistically significant differences favoring the digital self-directed learning group, affirming the effectiveness of this study's approach. These insights have broader implications for similar challenges in digital literacy skill development across various higher education settings. The adaptable nature of Design Thinking makes it a valuable strategy for institutions addressing comparable digital literacy issues. Nevertheless, it's important to note that the study's generalizability might be limited by its specific sample size and contextual constraints. Future research could explore a broader range of student demographics and educational settings to validate the effectiveness of the Design Thinking approach in enhancing digital literacy. This could include integrating design thinking with alternative digital learning and teaching methods to further improve digital literacy.

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