International Journal of Science Education and Teaching
Vol. 4, No. 2, pp. 126-140, May. – Aug. 2025
http://doi.org/10.14456/ijset.2025.09

Learning Management Platform to Enhance Computational Thinking in Computer Science Using a Flipped Classroom Technique for 6th Grade Students

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Received: 22 Jun. 2025 Revised: 21 Jul. 2025 Accepted: 24 Jul. 2025

Abstract. The objectives of this research were: 1) to develop a learning management platform to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students; 2) to evaluate the efficiency of the learning management platform for enhancing computational thinking in computer science using a flipped classroom technique, according to the 80/80 standard criteria; 3) to determine the effectiveness index and learning achievement of the developed platform; and 4) to study the level of expert opinion on learning with the developed platform. The sample group consisted of 50 6th grade students from Assumption College Thonburi, Bangkok, selected through cluster random sampling with classrooms as the sampling unit, and 10 experts in educational innovation and technology selected using purposive sampling. The research instruments used were: 1) the learning management platform for enhancing computational thinking in computer science using a flipped classroom technique, 2) a learning achievement test, and 3) a platform quality evaluation form by experts. The statistics used for data analysis were percentage, mean, standard deviation, and *t*-test. The research revealed that the developed learning management platform for enhancing computational thinking in computer science using a flipped classroom technique had an efficiency of 81.55/83.98, which aligns with the 80/80 standard criteria. The effectiveness index was 0.8314. Students who learned with the system showed significantly higher post-test learning achievement than pre-test learning achievement at a statistical significance level of 0.05. Experts had a high level of opinion regarding the learning management platform for enhancing computational thinking in computer science using a flipped classroom technique. The research results yielded a prototype learning management platform to enhance computational thinking in computer science for 6th grade students that is efficient, can be practically used in teaching and learning, and enables learners to acquire skills and develop learning in computer science for subsequent science learning.

Keywords: Learning Management Platform; Computational Thinking; Computer Science; Flipped Classroom Technique

INTRODUCTION

The United Nations has established the Sustainable Development Goals (SDGs) for member states to achieve by 2030, focusing on social, economic, and environmental progress. Effective and high-quality education forms a crucial foundation for human resource development, which is fundamental to a nation's stable and sustainable growth. The National Education Act (No. 4) B.E. 2562 (2019) and the 13th National Economic and Social Development Plan B.E. 2566-2570 (2023-2027) have outlined key emphases for quality development, guiding curriculum, learning management, and assessment with the aim of significantly improving learner quality (Ministry of Education, 2019). Consequently, the Ministry of Education has mandated educational reform in line with the 20-year National Strategy, envisioning that "Thais will learn throughout life with quality." This systemic reform of education and learning primarily focuses on three key areas: enhancing the quality of education and learning, increasing educational opportunities and access to quality learning for all Thais, and fostering participation from all sectors of society. New guidelines have been established to develop quality across five areas: Thai citizens, teachers, learners, educational institutions, and administration. Specifically, basic education is encouraged to adapt learning models to be contemporary, implement systematic and clear operational plans for practical execution, and develop high-quality learning materials that respond to the evolving learning situations in the digital education era (Ministry of Education, 2023).

Learning Management Systems (LMS), including teaching and learning management using Digital Platforms, are methods employed to enhance potential and solve problems in current learning, where learning styles and methods must be blended for maximum quality. This allows instructors to prepare lessons with diverse learning media, enables learners to review content retrospectively, and provides learners with access to learning resources anytime, anywhere via designed online channels. Clear teaching objectives are set, pedagogical theories guide management, and content is presented in multimedia format through systematic network and educational platforms. This helps learners acquire new knowledge and skills or significantly improve their existing knowledge and abilities (Kant et al., 2021; Samaila & Al-Samarraie, 2024). Additionally, digital platforms can enable learners to learn independently, providing immediate and effective feedback, allowing learners to know their learning progress quickly. They can also help increase learner motivation through program design that includes images, sounds, multimedia, and fast interaction with learners. The era of transformative education (Education Disruption) has brought diverse learning management models to promote and solve various educational challenges. Therefore, learning management must adapt to new learning paradigms, enabling learners to be self-directed in seeking knowledge, especially in fully utilizing educational innovations and technologies for knowledge acquisition (Sinlarat, 2020; Phakamach, 2023; Phakamach et al., 2024a).

Computational Thinking (CT) refers to a systematic, step-by-step problem-solving process applicable by both humans and computers. The benefits of CT include: 1) simplifying complex problems, 2) enhancing problem comprehension, 3) effectively communicating concepts to others, 4) providing a foundation for computer programming, and 5) developing systematic thinking skills (Tsortanidou et al., 2019; Weinhandl et al., 2020; Ramírez-Montoya & Portuguez-Castro, 2024). CT benefits learning by helping learners to: 1) better comprehend and solve computational science problems, 2) apply these concepts to real-world problems, and 3) develop creative thinking and problem-solving skills. Practical applications of CT, particularly within a STEM approach for daily life situations, include travel planning, time management, solving mathematical problems, and computer programming. Therefore, computational thinking is an essential skill for problem-solving and fostering intellectual development in the digital education era, enabling learners to grasp and apply these concepts across diverse situations (Champion et al., 2020; Lai, 2024; Hidayat et al., 2024). The Flipped Classroom model has also been widely adopted to enhance teaching and learning and address educational challenges in an era characterized by diverse information sources and ICT media (Jian, 2018; Nachatar Singh et al., 2019). This is because the flipped classroom learning model focuses on students' knowledge construction based on their individual skills, knowledge, abilities, and intelligence. It also empowers learners with freedom in thought and methods for seeking knowledge from external learning resources, fostering analytical thinking, problem-solving, creativity, and student interaction. Its emphasis on inquiry-based, learner-centered instruction promotes and supports students, perfectly aligning with contemporary educational shifts (Weinhandl et al., 2020; Latorre-Cosculluela et al., 2021; Chaisena et al., 2022; Hwang et al., 2023; Suwardika et al., 2024).

Furthermore, in the 21st century, the learning paradigm has shifted the teacher's role from that of a lecturer to a facilitator of the learning process, designing pedagogical activities that empower students to independently learn and construct knowledge. As a facilitator, the teacher guides students and suggests tools for efficient and seamless knowledge access and learning activities through various methods, especially via technology or learning management systems (Phakamach, 2023). This acquired knowledge is then exchanged with peers in the classroom, a learning process known as Active Learning, which is student-centered. Moreover, the flipped classroom model is widely discussed and applied today due to its ability to foster 21st Century Skills by leveraging modern educational technology and offering learners opportunities for diverse activities (Smith, 2021). Therefore, applying the flipped classroom model in conjunction with a learning management system, particularly for practical computational courses, can significantly enhance the efficiency and effectiveness of science education, leading to improved student learning outcomes (Jian, 2018; Ironsi, 2022; Pereira Bueno et al., 2023; Samaila & Al-Samarraie, 2024; Suwardika et al., 2024).

Based on these concepts, the researchers are interested in developing a learning management platform to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students, employing a Research and Development (R&D) methodology. This aims to create a learning management platform that enhances computational thinking in computer science using a flipped classroom technique for 6th grade students, applying educational innovation and technology as supplementary tools in managing instruction for this subject. The process involves blended online learning network management, used for conducting teaching and learning activities in computer science, creating a digital for learning environment based on computational thinking. It is expected that the developed platform and learning management model will help primary school students learn collaboratively in the classroom to enhance their computational learning competencies, achieve learning outcomes quickly, and serve as a guideline for spreading knowledge in schools that use ICT systems and educational innovations in their teaching.

RESEARCH OBJECTIVES

The study had four research objectives were as follows:

1. To develop a learning management platform to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students.

2. To evaluate the efficiency of the developed learning management platform for enhancing computational thinking in computer science using a flipped classroom technique, according to the 80/80 standard criteria.

3. To determine the effectiveness index and learning achievement of the learning management platform for enhancing computational thinking in computer science using a flipped classroom technique.

4. To study the level of expert opinion on learning with the learning management platform to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students.

LITERATURE REVIEW

The 21st century is characterized by rapid technological advancements and a growing emphasis on digital literacy and critical thinking skills. In this context, computational thinking (CT) has emerged as a fundamental skill set crucial for navigating and contributing to the modern world. Recognizing its importance, educational systems globally, including Thailand, are integrating computer science (CS) concepts into primary education curricula. This literature review explores the interconnected roles of Learning Management Platforms (LMPs) and the flipped classroom (FC) technique as a synergistic pedagogical approach to enhance computational thinking skills specifically in 6th-grade students studying computer science.

The Imperative for 21st Century Skills and Computational Thinking

The United Nations' Sustainable Development Goals (SDGs) and national educational policies, such as Thailand's National Education Act (No. 4) B.E. 2562 (2019) and the 13th National Economic and Social Development Plan B.E. 2566-2570 (2023-2027), underscore the critical need for quality education to develop human resources capable of fostering sustainable societal progress. This involves systemic educational reform, focusing on improving learning quality, expanding educational opportunities, and ensuring access to quality learning for all (Ministry of Education, 2019, 2023). A core aspect of this reform is adapting learning models to current situations and producing high-quality teaching media responsive to the digital education era (Phakamach et al., 2024a).

Central to this educational evolution is computational thinking, defined as a problem-solving process that employs systematic and step-by-step methods, applicable by both humans and computers. CT encompasses key components such as decomposition, pattern recognition, abstraction, and algorithmic thinking (Tsortanidou et al., 2019; Weinhandl et al., 2020; Ramírez-Montoya & Portuguez-Castro, 2024). For 6th-grade students, CT is not merely about programming but about developing a logical, analytical, and creative approach to problem-solving. Its benefits extend to simplifying complex problems, enhancing problem comprehension, improving communication of ideas, building foundational programming skills, and fostering systematic thinking. Moreover, CT supports creative thinking and problem-solving in various real-life scenarios, such as travel planning, time management, and mathematical problem-solving, making it an indispensable skill in the digital age (Champion et al., 2020; Lai, 2024; Hidayat et al., 2024).

The Flipped Classroom Model in Educational Transformation

The landscape of education is undergoing significant transformation, often termed "Education Disruption," demanding flexible and innovative instructional models. The flipped classroom model stands out as a prominent approach addressing these demands. It inverts the traditional learning setup by moving direct instruction outside the classroom (e.g., through pre-recorded videos, online readings) and dedicating in-class time to active, hands-on activities, problem-solving, and collaborative learning (Jian, 2018; Nachatar Singh et al., 2019).

For primary school students, the flipped classroom model offers several advantages. It empowers students to construct knowledge based on their individual skills, abilities, and intelligence, providing freedom in thought and knowledge acquisition from external learning resources. This fosters analytical thinking, problem-solving, creativity, and interaction among learners. By emphasizing inquiry-based, student-centered learning, the flipped classroom aligns well with contemporary educational paradigms (Weinhandl et al., 2020; Latorre-Cosculluela et al., 2021; Chaisena et al., 2022; Hwang et al., 2023; Suwardika et al., 2024). In the 21st century, the teacher's role shifts from a lecturer to a facilitator and activity designer, guiding students to construct knowledge through active learning and collaborative engagement (Phakamach, 2023). This model is particularly effective in cultivating 21st century skills by leveraging modern instructional technology and providing diverse learning activities (Smith, 2021; Leão et al., 2023).

The Role of Learning Management Platforms

Learning Management Systems (LMS) and Digital Platforms are integral components of modern educational ecosystems, providing a robust infrastructure to support enhanced learning experiences. These platforms are crucial for addressing contemporary learning challenges, particularly when integrating diverse teaching methods for optimal quality. They empower instructors to organize a variety of learning media, enable students to review content at their convenience, and facilitate ubiquitous access to learning resources online (Kant et al., 2021; Samaila & Al-Samarraie, 2024).

LMPs are designed with clear instructional objectives, guided by pedagogical theories, and present content through multimedia formats via systematic educational networks and platforms. This systematic approach effectively promotes knowledge acquisition and skill development or improvement (Phakamach et al., 2024b). Moreover, digital platforms support independent learning by providing immediate and effective feedback, allowing learners to track their progress quickly.

Features like engaging visuals, sounds, and interactive multimedia can significantly boost student motivation (Jian, 2018; Zainuddin et al., 2019; Chaisena et al. 2022; Lantu et al., 2023; Suwardika et al., 2024). The flexibility and rich features of LMPs make them essential tools for implementing blended learning and flipped classroom models, especially in subjects like computer science that benefit from interactive and self-paced learning.

Integrating the Flipped Classroom and Learning Management Platforms for Computational Thinking in 6th Grade Computer Science

The synergy between the flipped classroom model and learning management platforms offers a powerful approach to enhancing computational thinking in computer science for 6th-grade students. The LMP serves as the primary conduit for delivering pre-class instructional content, including foundational concepts of computational thinking, interactive tutorials, and virtual learning media. This pre-engagement allows students to absorb basic knowledge at their own pace, ensuring they arrive in the classroom with a shared baseline understanding.

In the classroom, the freed-up time can be dedicated to active learning activities and collaborative problem-solving, where students apply their newfound CT skills. This can involve hands-on coding challenges, debugging exercises, or group projects that require logical reasoning and algorithmic thinking. The teacher transitions into a facilitator role, providing personalized guidance, clarifying misconceptions, and fostering deeper conceptual understanding. The LMP further supports this by providing tools for practice exercises, tracking student progress, and offering instant feedback, which is crucial for the iterative development of CT skills (Leão et al., 2023).

Research indicates that the systematic development of such integrated learning environments, following models like ADDIE (Analysis, Design, Development, Implementation, Evaluation), and incorporating expert reviews, leads to highly effective platforms. Studies show that learning management platforms designed with active learning components, engaging multimedia, and robust support systems can significantly improve student engagement, learning achievement, and the acquisition of computational thinking skills (Chaisena et al., 2022; Ironsi, 2022; Lantu et al., 2023; Hwang et al., 2023; Leão et al., 2023; Phakamach et al., 2024b; Samaila & Al-Samarraie, 2024; Suwardika et al., 2024). The positive impact on learning outcomes, as evidenced by significant gains in post-test scores and high effectiveness indices, underscores the potential of this integrated approach. From previous research reports, it can also be concluded that ADDIE significantly contributes to student learning outcomes at each stage, as follows: 1) Analysis: Helps in understanding learner needs and clarifying learning objectives, leading to precisely defined learning outcome goals; 2) Design: Involves planning content structure, instructional strategies, and activities that align with objectives, enabling learners to achieve the set outcomes; 3) Development: Creates learning materials and platforms according to the design, providing appropriate tools to facilitate learning; 4) Implementation: Applies the developed plans and materials in the actual learning environment, facilitating learner engagement; and 5) Evaluation: Assesses the effectiveness of the learning and the platform to identify strengths, weaknesses, and make continuous improvements for enhanced learning outcomes. Furthermore, positive expert opinions on the platform's components, design, and usability confirm its quality and suitability for practical implementation in 6th-grade computer science education.

In summary, the integration of a learning management platform with the flipped classroom technique presents an effective and efficient pedagogical model for enhancing computational thinking in 6th-grade computer science students. This approach aligns with national educational goals and the global imperative for developing 21st century skills. By enabling flexible pre-class learning and maximizing in-class time for active, collaborative application of computational thinking, this integrated model fosters deeper understanding, improves learning outcomes, and cultivates essential problem-solving abilities. The consistent positive findings from various studies and expert evaluations support the viability and quality of such platforms. As education continues to evolve, further research and development in this area will be crucial to refine these models and expand modern scientific learning resources for basic education.

RESEARCH CONCEPTUAL FRAMEWORK

Based on the literature review, documents, articles, and various related research reports, the researchers designed the research methodology by defining a conceptual framework for developing a learning management platform to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students, as shown in Figure 1.

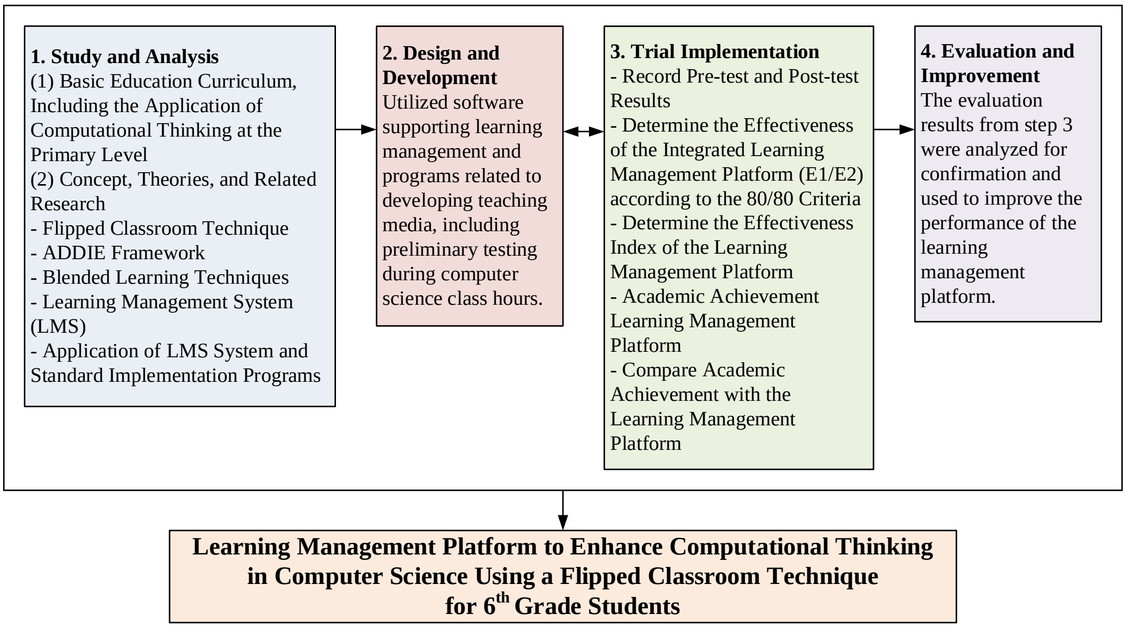


Figure 1: Research Conceptual Framework.

METHODOLOGY

This research includes research and development with related details as follows:

Population and Sample

The population for this research consisted of 50 primary school students enrolled in the Computer Science course during the first semester of the academic year 2025 at Assumption College Thonburi, Bangkok. The sample was obtained through cluster random sampling of mathematics and science classrooms, with the classroom as the sampling unit. Additionally, 10 experts in educational innovation and technology were chosen via purposive sampling.

Research Instruments

The research instruments included: (1) the LMP developed to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students, (2) a learning achievement test, (3) a system quality evaluation form completed by experts, and (4) an expert opinion questionnaire and interview guide regarding the LMP for enhancing computational thinking in computer science using a flipped classroom technique for 6th grade students. This was informed by the research of Chaisena et al. (2022), Hwang et al. (2023), and Lai (2024).

The construction and validation of the questionnaire instruments involved presentation to experts to check content validity, as well as the appropriateness of language and wording. An Index of Item-objective Congruence (IOC) score of 0.91 was obtained. The questionnaire was then piloted, and its reliability was determined using Cronbach's Alpha Coefficient, yielding an overall questionnaire reliability of 0.937. The item discrimination was calculated using the Item Total Correlation.

Research Procedure

As this research employed a Research and Development (R&D) methodology, the researchers outlined four sequential steps to cover the research objectives:

1. Study and Analysis: This involved studying and analyzing data related to the basic education curriculum, including the application of computational thinking at the primary level, drawing from relevant documents and research reports.

2. Design and Development: This phase utilized software supporting learning management and programs related to developing teaching media, including preliminary testing during computer science class hours.

3. Trial Implementation: This stage involved a 3-month trial period to test efficiency, calculate the effectiveness index, and measure the learning achievement of students enrolled in the computer science course.

4. Evaluation and Improvement: The evaluation results from step 3 were analyzed for confirmation and used to improve the performance of the learning management platform designed to enhance computational thinking in computer science using a flipped classroom technique for 6^{th} grade students, ensuring it met specified performance criteria.

Steps for Creating Online Learning Instruments

The steps for creating online learning instruments included: (1) studying the curriculum/course and analyzing the content of the Computer Science course, (2) defining learning objectives to determine the scope of content for each learning unit, (3) defining the content presentation format, (4) writing a Flowchart for the lessons to define internal communication channels, (5) designing a Storyboard based on a hierarchical structure using the flipped classroom model, (6) developing the format using the LMS Tool Box and computer programs, (7) piloting and revising the format, and (8) evaluating the quality and efficiency of the developed platform.

Experiment and Data Collection

1. Location: The experiment was conducted at Assumption College Thonburi, Bangkok.

2. Preparation for the Experiment included: (1) obtaining permission to collect data and pilot the system, (2) preparing the developed system for online website deployment, uploading data to the server, and testing its functionality, and (3) preparing the venue, computers, connection equipment, and scheduling the experiment time.

3. Conducting the Experiment: The system, after expert evaluation, was piloted to assess its efficiency using the following experimental designs (Fernández et al., 2016):

3.1 One-to-One Testing: Conducted with 3 students who had previously taken the course, selected by simple random sampling. Efficiency (E_1/E_2) was evaluated to identify flaws and make improvements, yielding an E_1/E_2 value of 61.36/62.19.

3.2 Small Group Testing: Conducted with 9 students who had previously enrolled in the course, selected by simple random sampling. Efficiency (E_1/E_2) was evaluated to identify flaws and make improvements, yielding an E_1/E_2 value of 71.45/72.58.

3.3 Field Testing: Conducted with a sample group of 50 students, following these steps: (1) A Pretest was administered using a 40-item learning achievement test. (2) Students learned using the developed platform. (3) Students completed exercises from the developed platform, 10 items per learning unit. (4) A Posttest was administered using the same 40-item learning achievement test. The overall efficiency (E_1/E_2) was evaluated, yielding an E_1/E_2 value of 81.55/83.98.

Data Analysis

The researchers analyzed the collected data using statistical computer programs, as follows:

1. Development of the LMP to enhance computational thinking in computer science using a flipped classroom technique for 6^{th} grade students involved:

1.1 Evaluation of a learning management platform's quality, assessed by 10 educational innovation and technology experts using a 5-point Likert scale. The interpretation criteria were:

4.51 – 5.00: Highest quality;
3.51 – 4.50: High quality;
2.51 – 3.50: Moderate quality;
1.51 – 2.50: Low quality; and

1.00 – 1.50: Lowest quality.

1.2 Efficiency analysis of the platform included: (1) calculating basic statistics (percentage, mean score, and standard deviation) from each learning unit's test scores and post-learning achievement scores, (2) determining efficiency according to the 80/80 criteria, (3) calculating the effectiveness index, (4) comparing pre-test and post-test learning achievement using *t*-test statistics, and (5) analyzing expert opinions on learning with the platform by calculating the mean ($\bar{x}$) and standard deviation (S.D) and comparing the mean to the set criteria using a 5-point Likert scale.

2. Statistics used to determine the quality of the learning achievement test included: (1) Discrimination index using Brennan's criterion-referenced analysis, (2) Difficulty level, (3) Content validity of each test item using the IOC formula, and (4) Reliability of the test using Kuder-Richardson's KR20 formula.

3. Statistics used to calculate the effectiveness index employed Goodman, Fletcher, and Schneider's method.

4. Calculation of the efficiency of the platform according to the 80/80 standard criteria used a specific formula.

5. Comparison of the difference between pre-test and post-test scores used a dependent samples *t*-test with its corresponding formula.

6. Data from the interviews and expert discussions were analyzed using descriptive content analysis.

RESULTS

Based on the research titled "Learning Management Platform to Enhance Computational Thinking in Computer Science Using a Flipped Classroom Technique for 6th Grade Students," the research findings and data analysis, aligned with the research objectives, are as follows:

1. Results of Developing the Learning Management Platform

The developed LMP to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students was designed using a LMS that incorporates computer science content. It aims to strengthen computational thinking as a foundation, preparing students with knowledge and interest in higher levels of science and technology. Additionally, the flipped classroom technique is employed to enable students to practice learning outside of regular class hours through virtual learning content and media. Therefore, the platform's design, based on the presented methodology, ensures sufficient quality for its practical implementation.

2. Results of Evaluating the Platform's Efficiency

The evaluation of the LMP's efficiency in enhancing computational thinking in computer science using a flipped classroom technique for 6th grade students, which met the 80/80 standard criteria, revealed an efficiency of 81.55/83.98. This means that the developed platform facilitated a learning process efficiency of 81.55% and a learning performance efficiency (change in student behavior) of 83.98%. Thus, it met the 80/80 standard criteria as intended by the research objectives.

3. Results of Determining the Effectiveness Index and Learning Achievement

The effectiveness index of the developed LMP to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students was 0.8314 (83.14%). Regarding the learning achievement of students who learned with the developed platform, the average pre-test score was 15.64 out of a total of 30, equivalent to 50.46%. The average post-test score was 23.87 out of a total of 30, equivalent to 73.45%. When the obtained average scores were subjected to a *t*-test (t=22.471), it was found that the post-test scores were significantly higher than the pre-test scores at a statistical significance level of 0.05, as shown in Table 1.

Table 1: Comparison of Students' Learning Achievement Before and After Learning.

Learning Achievement	*n*	$\bar{x}$	S.D.	*t*	*p*-value
Pretest	50	15.64	0.574	22.471	.001
Posttest	50	23.87	0.628		

* Statistically significant at the level of .05.

4. Expert Opinion on Platform Quality Evaluation Results

The results of the study to evaluate the quality based on the opinions of 10 experts in educational innovation and technology regarding the LMP to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students as shown in Table 2.

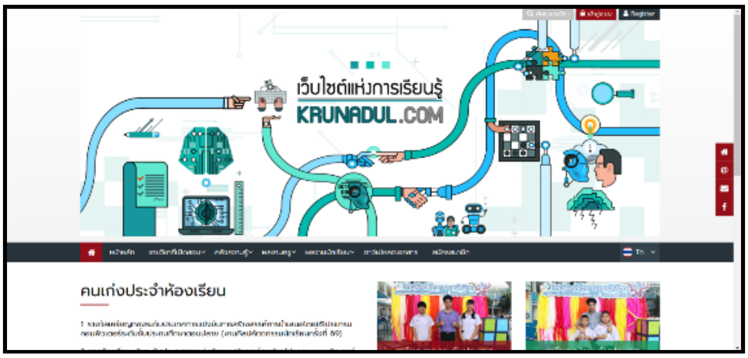
Table 2: Expert Evaluation Results of Platform Quality.

Topics and Assessment Items		$\bar{x}$	S.D.	Interpreting
System Components and Learning Activities	1. Learning Management Platform	4.10	0.60	High
	2. Record knowledge	4.00	0.55	High
	3. Measuring and evaluating knowledge	4.13	0.65	High
	4. Discussion board	4.10	0.55	High
	5. Knowledge repository and exchange	4.20	0.50	High
	6. Active learning activities	4.44	0.65	Highest
	7. Pictures of various activities	4.32	0.60	Highest
Design and Development	8. Content and Consistency	4.38	0.65	Highest
	9. Format and font size	3.99	0.55	High
	10. Font color and background	4.04	0.60	High
	11. Visual and sound effects	4.23	0.55	High
	12. Multimedia system	3.69	0.65	High
	13. Instructions and Manuals	4.24	0.60	High
	14. Overall screen interface and activities	4.35	0.55	Highest
	15. Design and development process	4.29	0.60	Highest
Usability and Attitude	16. Membership system	4.04	0.50	High
	17. Back-end system	4.14	0.65	High
	18. Link section with AI interface	4.40	0.55	Highest
	19. Interaction section	3.90	0.65	High
	20. Search system	4.32	0.50	Highest
	21. How to use it for the purpose	4.44	0.65	Highest
	22. Practice in the course	4.17	0.60	High
Total		**4.17**	**0.55**	**High**

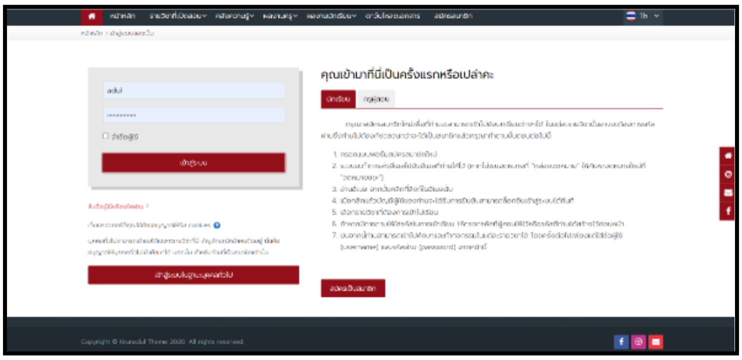
From table 2, the quality evaluation of the LMP to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students, assessed by experts across three dimensions, revealed an overall average quality at a high level ($\bar{x}$= 4.17). When considering each dimension, the findings were as follows: System Components and Learning Activities (7 items): The overall average was at a high level ($\bar{x}$= 4.18). Ranking the average scores from highest to lowest: 1) Active learning activities, 2) Pictures of various activities, and 3) Knowledge repository and exchange. Design and Development (8 items): The overall average was at a high level ($\bar{x}$= 4.15). Ranking the average scores from highest to lowest: 1) Content and Consistency, 2) Overall screen interface and activities, and 3) Design and development process. Usability and Attitude (7 items): The overall average was at a high level ($\bar{x}$ =4.20). Ranking the average scores from highest to lowest: 1) How to use it for the purpose, 2) Link section with AI interface, and 3) Search system.

Furthermore, the focus group discussions with 10 experts in educational innovation and technology centered on five key areas: (1) design and development processes, (2) content and presentation, (3) learning activities and problem-solving, (4) implementation, and (5) recommendations. The experts collectively confirmed that the developed learning management platform adheres to standard design and development processes and can effectively be used for instruction within the subject, potentially through a blended learning approach. Moreover, the platform's design and development process can serve as a prototype for other schools to develop their own learning management models. However, the experts also suggested that for future educational terms, the content and learning activities should be further developed with more case studies to help students achieve the subject's learning outcomes, foster positive computational thinking development, and encourage greater educational innovation.

Examples of the improved LMP to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students as shown in Figures 2-6. These include, respectively: Figure 2: Learning Management Platform to Enhance Computational Thinking in Computer Science Using a Flipped Classroom Technique for 6th Grade Students where (a) is homepage of platform and (b) is login window of platform, Figure 3: Computer Science Learning Units for 6th Grade, Figure 4: Example of Learning Unit Components, Figure 5: Example of Learning Skill Practice Activities, and Figure 6: Example of Online Teaching and Learning Activities.



(a) Homepage of Platform



(b) Login Window of Platform

Figure 2: Learning Management Platform to Enhance Computational Thinking in Computer Science Using a Flipped Classroom Technique for 6th Grade Students.

Figure 3: Computer Science Learning Units for 6th Grade.

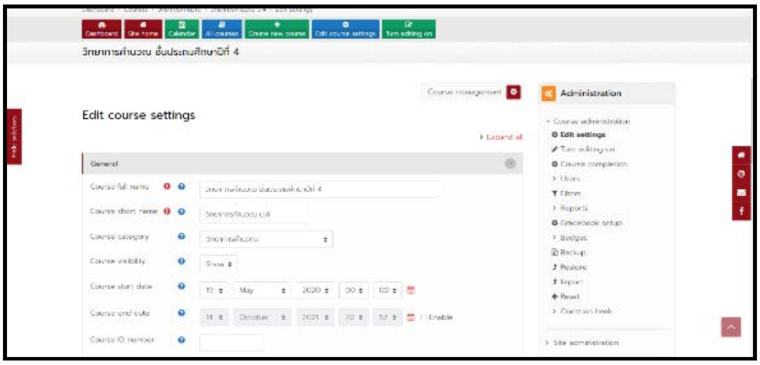


Figure 4: Example of Learning Unit Components.


Figure 5: Example of Learning Skill Practice Activities.

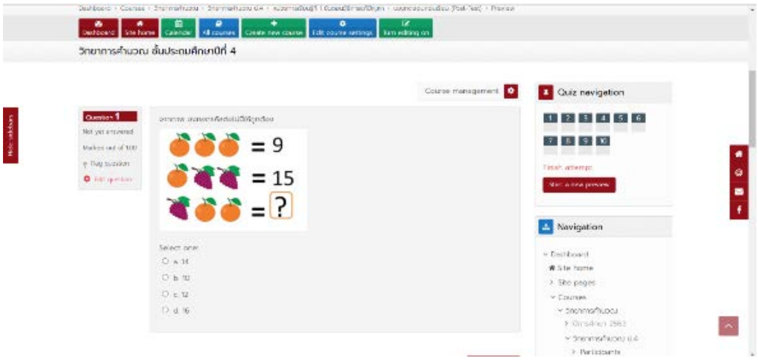


Figure 6: Example of Online Teaching and Learning Activities.

CONCLUSION AND DISCUSSION

Based on the research project titled "Learning Management Platform to Enhance Computational Thinking in Computer Science Using a Flipped Classroom Technique for 6th Grade Students," the research findings and data analysis could be summarized and discussed in alignment with the objectives and research procedures were as follows:

1. Development of the Learning Management Platform

The developed LMP to enhance computational thinking in computer science using a flipped classroom technique for 6th grade students was designed by the researchers based on conceptual frameworks from Jian (2018), Zainuddin et al. (2019), Champion et al. (2020), Chaisena et al. (2022), Hwang et al. (2023), Phakamach et al. (2024b), and Samaila and Al-Samarraie (2024) for LMS design. The key design principles included: 1) content analysis of the subject, 2) instructional design based on flipped classroom principles utilizing collaborative learning (which involved: (1) studying the problem to be analyzed, (2) gathering and processing the problem, (3) developing possible solutions, (4) testing the solutions, and (5) selecting the best learning model to find answers), 3) defining joint activities and knowledge processing, 4) conducting instruction with models and teaching media using designated communication channels, and 5) testing the efficiency of the learning model by considering learning achievement scores and end-of-chapter exercise scores.

2. Efficiency of the Learning Management Platform

The results from testing the efficiency of the developed LMP to enhance computational thinking in computer science using a flipped classroom technique for 6^{th} grade students showed an efficiency of 81.44/83.89. This means that the LMP led to an 81.44% efficiency in the learning process and an 83.89% efficiency in learning (or the effectiveness of the learning model and teaching media in changing student behavior). This demonstrated that the developed platform met the 80/80 standard criteria and could satisfactorily help students improve their learning progress in computer science. These findings were consistent with the research of Chaisena et al. (2022), Ironsi (2022), Lantu et al. (2023), Hwang et al. (2023), Errabo et al. (2024), and Şahin and Kılıç (2025). This could be attributed to the following reasons:

2.1 The LMP had average scores higher than the set standard criteria. This was because the researchers systematically developed the LMS, from studying and analyzing data using the ADDIE model process to designing computer science content based on the flipped classroom activity design steps that enhance computational thinking. This content was reviewed and revised by subject matter experts. Subsequently, it was reviewed by educational innovation and technology experts before being piloted with the sample group to evaluate its efficiency and improve it based on the results. This aligns with the media production and learning model development process of Research and Development (R&D). The used of standard LMS Tool Boxes for creating content, problems, and interactive components in the computer science classroom is consistent with the research of Jian (2018), Chaisena et al. (2022), Hwang et al. (2023), Leão et al. (2023), Phakamach et al. (2024b), Samaila and Al-Samarraie (2024), and Suwardika et al. (2024). Therefore, 6^{th} grade students gained a better understanding of computer science learning.

2.2 The developed LMP included robust learning management support and tracking systems to ensure students achieved the specified computational thinking learning outcomes, covering content, research, knowledge processing, discussion, critical thinking, and collaborative conclusions.

3. Effectiveness Index and Learning Achievement

The effectiveness index of the developed LMP to enhance computational thinking in computer science using a flipped classroom technique for 6^{th} grade students was 0.8314. This means that after learning with this platform, scores increased by 83.14%. This finding was consistent with the research of Jian (2018), Zainuddin et al. (2019), Chaisena et al. (2022), and Hwang et al. (2023). This was because the platform's presentation format mimics direct instruction from a teacher. It enhanced understanding through collaborative learning processes, incorporating text, graphics, still images, animations, and multimedia, making learning enjoyable and engaging for students. It also provided reinforcing feedback, drawing from Malone's motivation theory, where the instructional design included challenging activities and situations with critical learning objectives. Students' imagination was stimulated, and novel presentations continuously capture their attention, fostering curiosity and a desire to learn new things (Jian, 2018; Zainuddin et al., 2019; Chaisena et al. 2022; Lantu et al., 2023; Suwardika et al., 2024). For these reasons, 6^{th} grade students gained more knowledge and understanding in computer science, including its application in subsequent learning levels.

4. Expert Opinion on Platform Quality

The results of the quality evaluation based on expert opinions regarding learning with the developed LMP to enhance computational thinking in computer science using a flipped classroom technique for 6^{th} grade students revealed that experts rated the learning components and activities dimension at a high level ($\bar{x}$=4.18). This indicated that the flipped classroom learning components and activities used to create the learning management platform were appropriate and could create an efficient LMP. This was consistent with the research of Jian (2018), Smith (2021), Chaisena et al. (2022), Lantu et al. (2023), Hwang et al. (2023), and Suwardika et al. (2024). The design and development dimension were also rated at a high level ($\bar{x}$=4.15), indicating that the design process can create a good and appropriate quality LMP. Furthermore, the usability and attitude dimension were also rated at a high level ($\bar{x}$=4.20), clearly showing that the usability and student attitudes towards learning with the developed platform, including the media used, were appropriate and genuinely facilitate learning. This aligned with the research of Smith (2021), Bin-Hady and Hazaea (2022), Lantu et al. (2023), Hwang et al. (2023), Samaila and Al-Samarraie (2024), and Suwardika et al. (2024). This was because student attitude towards the lesson was crucial for improving the quality of the system and media used, providing clearer insights into students' actual needs. Allowing students to choose what they learn independently is part of a good learning process and leads to better learning through collaborative classroom experiences.

Therefore, it could be concluded that the research and development on "Learning Management Platform to Enhance Computational Thinking in Computer Science Using a Flipped Classroom Technique for 6th Grade Students," as presented, ensured sufficient quality for the practical implementation of this platform for learning management in computer science for 6th grade students. It could serve as a prototype for blended learning through offline and online processes, and this learning management model could be further developed to be completer and more efficient in the future.

RECOMMENDATIONS

The researchers put forward two kinds of feedback as follows:

Recommendations for Implementation and Development

1) For the implementation and further enhancement of the LMP's performance, the following are recommended: (1) Lesson content must align with objectives and learning outcomes, (2) Learning objectives and problems should be clearly communicated to learners, (3) There should be a well-designed structure and clear learning path planning, (4) A system to verify that learners achieve learning outcomes and solve assigned problems is essential, (5) Learners should be encouraged to engage in Non-Linear Approach and Active Learning, (6) The platform should be developed to foster analytical and critical thinking, (7) Regular practical exercises with immediate feedback should be provided, (8) Access data, knowledge processing results, and usage should be recorded in a standardized format, and (9) In developing online learning systems, appropriate and consistent use of text, graphics, and multimedia is crucial to ensure efficient situational learning and information processing.

2) Before implementing this platform with elementary students at other schools, it's crucial to introduce the platform's format and processes to students. This will ensure they can use the platform and participate in classroom activities effectively, aligning with the objectives for teaching computational thinking.

3) To implement and assess CT to meet standards, focus on clear and measurable approaches:

(1) Clear Definition and Integration: CT components (decomposition, pattern recognition, abstraction, algorithms) should be clearly defined and integrated into curricula across various subjects, not just computer science. Specific learning outcomes should be identified, and activities designed to apply CT in diverse contexts, ensuring systematic understanding and practice.

(2) Practical and Problem-Solving Focused Learning Activities: Implement hands-on, problem-based learning activities where students actively apply CT skills through projects, coding, or complex problem-solving. Activities should encourage continuous critical thinking, planning, and refinement of solutions, which are core to CT development.

(3) Specific and Concrete Assessment: Assessment should directly measure CT skills beyond general achievement tests. Standard practices include using rubrics to evaluate code quality, problem-solving structure, or algorithm design. Additionally, observing behavior during problem-solving, analyzing student work, and using assessments specifically designed to measure individual CT components will yield accurate and reliable evaluation data.

Recommendations for Future Research

Recommendations for future research include:

1) Further development of this learning management platform to incorporate more standard learning media components, which would yield deeper insights for improving the efficiency of the learning management model.

2) Research and development of digital platforms that utilize Blended Learning and HyFlex models, capable of fostering more positive feelings and imagination in online learners through improved and more engaging multimedia.

3) The research should be conducted by piloting this developed platform with students from other educational institutions who are studying the same subject and have similar characteristics. This will provide comparative data for further developing the quality of this platform to be even more efficient and effective.

4) Further research and development of platforms or learning management models for other subjects to expand modern scientific learning resources for the continued development of basic education in Thailand.

ACKNOWLEDGEMENTS

The authors are grateful to acknowledge the support of Rattanakosin International College of Creative Entrepreneurship, Rajamangala University of Technology Rattanakosin and Advanced Future Talent Academy, Thailand.

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