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The learning management for computational thinking skill development based on STEMcompetency-based learning

Nakintorn Pattanachai [a], Saweya Suramane [b]
Unyaparn Sinlapaninman [c], Rotsarong Phattanaanusorn [d]*

[a,b,c,d] *Kalasin University, Department of Computer, Faculty of Education and Educational Innovation, Thailand*

Abstract

The purpose of this research was to 1) establish activities to develop computational thinking skills based on STEM competency learning management, 2) to study the Effectiveness Index of the learning management with competency-based learning based on STEM Education, 3) compare the computational thinking competencies of students majoring in Learning Management Innovation and 4) study students' satisfaction with the computational thinking skill development. The target group is first-year students majoring in Learning Management Innovation, Computer, Faculty of Education and Educational Innovation, Kalasin University that enrolled in Computational Science in Semester 1, Academic Year 2022. They were obtained through a purposive sampling of 14 people. The research instrument was the activities for computational thinking skill development based on STEM competency-based learning management, the suitability assessment form, academic achievement tests, computational skills competency assessments, and questionnaires on students' opinions on activities. The statistics used for data analysis were percentage, mean, standard deviation and t-test for One Sample. The results showed that; 1) The learning management for computational thinking skill development with STEM competency-based learning consists of five stages: problem identification, related information search, solution design, testing, evaluation and design improvement, and presentation, with the suitability level of 4.42 ± 0.50. 2) The Effectiveness Index of the activities is 0.66, resulting in the students' high learning progress. 3) on STEM competency-based learning of above the 70 percent threshold, with a statistical significance of .05. 4) The students were satisfied with the learning management, with 4.61 ± 0.52 at the highest level.

Keywords: Computational thinking skills; Competency-based learning; STEM education

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* Corresponding: Rotsarong Phattanaanusorn ORCID ID.: https://orcid.org/0009-0007-2910-9973
E-mail address: rotsarong.ph@ksu.ac.th

1. Introduction

1.1. Introduce the problem

The 12th National Economic and Social Development Plan 2017-2021 is central to workforce readiness and human potential, aiming at comprehensive development among people of all ages. The development of human potential mainly lies in skill development and equips people of each age with suitable sets of skills to ensure their future potential. Skill development responds to the labor market's demand and 21st century skills. Children and adolescents have critical and systematic thinking and creativity. The plan aims to upgrade basic education's quality, including small schools' administration, upgrading teaching approaches, and developing teachers' abilities. As stated in the 12th National Economic and Social Development Plan, the first strategy deals with the development of human potential and children and adolescents' critical and systematic thinking and creativity to ensure that they are equipped with enough working skills and life skills to join the labor market, with active learning process (Office of the National Economic and Social Development Board, 2017). Likewise, according to the National Plan for Education 2021 (Revised Edition) (Office of the Education Council, Ministry of Education, 2021) in accordance with the 20-Year National Strategy, the Committee for Education Reform aims that students in all levels receive proper education as specified in the second reform activity: The development of competency-based education to respond to the 21st changes based on the standard-based curriculum, with the target of student behaviors. It is required that students rely upon the integration of their potential and characteristics into active learning (National Plan for Education, 2021; National Research Council, 2011). Learner-based education refers to a learning process that is central to individuals' differences, wisdom, and learning process integrated with morals, satisfactory values which are conducive to students' active learning. The learning process aims students to develop their thinking, analyzing, studying, and experimenting process and seek new knowledge based on their capabilities and interests using integrated methods and processes which can be applied to life both in and outside the classroom. In addition, assessment is required to ensure that students meet the curriculum's objectives (Ministry of Education, 2001). Technological advances have an impact on the teaching of Computational Science, Learning Management Innovation, Computer Science, Faculty of Education and Educational Innovation, Kalasin University. The course implements activities which contribute to students' improved computational thinking skills, based on STEM education. The above-mentioned issues lead the teacher to develop students' computational thinking skill learning management based on competency-based learning to respond to the fast-changing 21st century. Therefore, the teacher apply STEM education-based to the teaching of the course, which is an integration of four interdisciplinary studies: science, engineering, technology, and mathematics. With this, students can apply the skills to their life and further develop new approaches which

would contribute to their lives and career path. This allows students to fulfill the undergraduate's objectives in the fifth aspect which refers to numerical analysis, communication, and the application of information technology (Office of the Higher Education Commission, 2009), comprising five steps: Step 1: Problem identification, Step 2: Related information search, Step 3: Solution design, Step 4: Testing, evaluation, and design improvement, and Step 5: Presentation **(**Bybee, R., 2010; Institute for the Promotion of Teaching Science and Technology, 2018**)**. As such, the teacher aim to study the development of computational thinking skills based on competency-based STEM education.

2. Research methods

2.1. Participants

The participants were 14 first-year students majoring in Learning Management Innovation, Computer, Faculty of Education and Educational Innovation, Kalasin University, that enrolled in Computational Science in Semester 1, Academic Year 2022 through purposive sampling.

2.2 Conceptual Framework

This study relies upon computational thinking skills which are instrumental in problem-solving in daily life as the skills are systematic and sensible. The skills enable students to grasp the problems through abstraction, which subsequently leads to systematic problem-solving process (Aho, A. V.2012; McKenna, 2017; Institute for the Promotion of Teaching Science and Technology, Ministry of Education, 2018) the development of competency-based learning to respond to the fast-changing 21st century (Nuangchalerm, P., 2017; National Plan for Education, 2021) and five steps of STEM education: Step 1: Problem identification, Step 2: Related information search, Step 3: Solution design, Step 4: Testing, evaluation, and design improvement, and Step 5: Presentation, to study and design learning management for computational thinking skill development based on STEM competency-based learning. The researchers' conceptual framework based on the principles and related information is as follows figure 1.

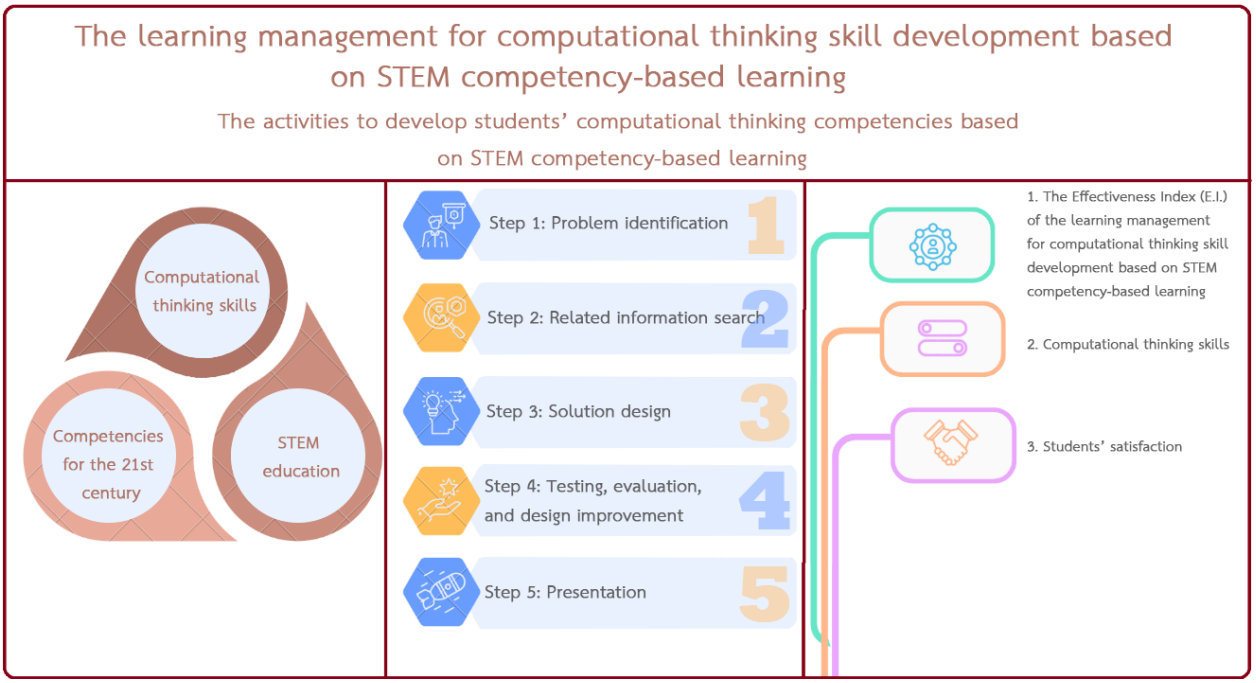

Figure 1. The research framework of learning management for computational thinking skill development based on STEM competency-based learning.

2.3 Research Methods

The researchers relied on five steps of research: literature review and related research, research tool development, tool efficiency analysis, experiment, and analysis and assessment as follows.

2.3.1 Review literature and related research

The researcher studied literature and related research on the basics of competency-based learning based on STEM education and the computational Science course.

2.3.2 Research tool development

The 18-weeks plan for the development of computational thinking skills based on STEM education's competency-based learning was implemented, with eight lessons regarding computational science learning management in order to fulfill the course's objectives. The design of teaching is based on five STEM education steps.

The 40-question four-option multiple choice tests in computational science was employed. The test covers eight lessons: 1) Introduction to computational science, 2) Computational thinking skills for problem-solving, 3) Algorithm, 4) Programming for solving science and mathematics problems, 5) Application development, 6) Primary

school computational science, 7) Middle school computational science, and 8) High school computational science.

The computational thinking skill questionnaires based on analytical rubrics scale which consist of four elements (Rodriguez, B. R., 2015): 1) Data Representation 2) Decomposition 3) Pattern Recognition 4) Abstraction and 5) Algorithmic Thinking with the threshold of 70%.

The satisfaction questionnaires on the learning management for the development of computational thinking skills based on STEM education's competency-based learning, with three sections: 1) Personal information, 2) Comments on three aspects, and 3) Suggestions.

2.3.3 Experiment

The pre-tests were given out to the students before the learning process. The teacher carried out the activities for computational thinking skill development based on STEM education's competency-based learning in the computational science course within 18 weeks, both physical class and online via Microsoft Teams program. After the learning process, the teacher measured students' competency using a computational thinking skill competency assessment form and satisfaction form of the activities for computational thinking skill development based on STEM education's competency-based learning.

3. Results

3.1 The results of the computational thinking skill development activities based on STEM competency-based learning.

The 18-weeks plan of the computational thinking skill development activities based on STEM competency-based learning, with eight lessons regarding computational science learning management in order to fulfill the course's objectives. The design of teaching is based on five STEM education steps: Step 1: Problem identification, Step 2: Related information search, Step 3: Solution design, Step 4: Testing, evaluation, and design improvement, and Step 5: Presentation. According to the assessment carried out by three experts, the suitability level is high ($\bar{X}$ = 4.42, S.D.=0.50), with steps and elements is shown in table 1.

Table 1. The learning plan for computational thinking skill development based on STEM competency-based learning

Activities/Steps	**Details**	
	Teachers' roles	**Students' roles**
Step 1 Introduction to the course The teachers give an explanation on the course's objectives and lessons.	1. Explaining the lessons in the course's curriculum 2. Explaining the teaching's approaches, discussion, and Q&A session 3. Explaining the concept mapping. 4. Explaining the course's scoring rubrics. 5. Delivering a lecture on the basics of computer science and methodical and systemic thinking for problem-solving. 6. Demonstrating how to use Microsoft Teams and Google Classroom.	1. Understanding the STEM education-based learning process 3. Understanding the computational science course's content,assignments, and activities based on STEM education.
Step 2 Learning process **Activity 1: Problem identification** Arousing the students' interest in the computer science issues which contributes to problem-solving through computer science**.**	1. Building a Computer Science class on Microsoft Teams and creating an atmosphere which is conducive to the course based on the content, with assorted instructional media, such as materials, documents for downloads, infographics, videos, slides, worksheets, links to educational sources, games, and tests. 2. Arousing the students' interest in the computer science issues. 3. Getting the students to determine the issue from scenarios.	1. Attending online and physical class. 2.Identifying an issue out of the provided scenarios.
Activity 2: Related information search Students seek to come up with ideas relating computer science based on STEM education's competency-based learning.	1. Creating an atmosphere which is conducive to the course based on the content, with assorted instructional media, such as materials, documents for downloads, infographics, and videos. 2. Recommending sources tools for computer science problem-solving and developing an application. 2.1 Scratch 2.2 Code.org (Code.org, (2015) 2.3 Logo Language 2.4 Python 3. Implementing teaching approaches which allow the students to participate in activities, delivering lectures, and assigning them to worksheets regarding	1. Attending online and physical class. 2. Understanding the lessons and the provided learning atmosphere. 3. Doing group activities through related information search and exchanging their ideas with members and teachers. 4. Completing assignments as provided in computational Science class on Microsoft Teams.

Activities/Steps	Details	
	Teachers' roles	**Students' roles**
	related information search in computational Science class on Microsoft Teams.	
Activity 3: Solution design The students design solutions based on computational science.	1. Creating an atmosphere which is conducive to the course based on the content, with assorted instructional media, such as materials, documents for downloads, infographics, and videos. 2. Implementing teaching approaches which allow the students to participate in activities, delivering lectures, and assigning them to worksheets regarding related information search in Computational Science class on Microsoft Teams.	1. Attending online and physical class. 2. Understanding the lessons and the provided learning atmosphere. 3. Doing group activities through related information search and exchanging their ideas with members and teachers. 4. Utilizing tools to assisting in planning on solutions. 4.1 Narrative description and the use of natural language in writing algorithms. 4.3 Flowcharts 4.4 Pseudo-Code 5. Completing assignments as provided in computational Science class on Microsoft Teams.
Activity 4: Testing, evaluation and design improvement After design improvement, the students shall check whether they complete all assignments. If not, they are allowed to improve their assignments.	1. Giving feedback on the students' assignments.	1. Checking whether they complete all assignments. If not, they are allowed to improve their assignments.
Activity 5: Presentation The students shall submit all the assignments and reflect their ideas toward the issues on Microsoft Teams.	1. Giving feedback on the students' assignments regarding solution tools and approaches.	1. Submitting all the assignments and reflect their ideas toward the issues1
Step 3 Competency assessment and conclusion	1. Evaluating learning's achievements. 2. Conducting a 360-degree assessment in the computational thinking skill from self-assessment, assessment by the classmates, and assessment by the	1. Taking post-tests. 2. Conducting a 360-degree assessment in the computational thinking skill from self-assessment, assessment by the classmates, and

Activities/Steps	Details	
	Teachers' roles	**Students' roles**
	teachers. 3. Conducting a satisfaction assessment with the computational thinking skill development activities based on STEM competency-based learning. 4. Reflecting the results of learning to the students.	assessment by the teachers. 3. Conducting a satisfaction assessment of the computational thinking skill development activities based on STEM competency-based learning. 4. Reflecting the results of learning with the classmates and teachers.

Table 1 shows the computational thinking skill development activities based on STEM competency-based learning, comprising three steps. Step 1 is the introduction to the course, including 1) the explanation of the course's curriculum, 2) the explanation of teaching approaches, discussion, and Q&A session, 3) the explanation of the concept mapping, 4) the explanation of scoring rubrics, 5) the lecture of the basics of computer science and methodical and systematic problem-solving, and 6) the demonstration of how to use Microsoft Teams and Google Classroom. Step 2 is the learning process, including Activity 1: Problem identification, Activity 2: Related information search, Activity 3: Solution design, Activity 4: Testing, evaluation, and design improvement, and Activity 5: Presentation. Step 3 is the competency assessment and conclusion, including 1) the assessment of learning's performance, 2) the 360-degree assessment of computational thinking skill, including self-assessment, assessment by the teachers, and assessment by the classmates, 3) the satisfaction assessment of the computational thinking skill development activities based on STEM competency-based learning, 4) the reflection of learning to the students.

3.2 The results of the Effectiveness Index (E.I.) of the computational thinking skill development activities based on STEM competency-based learning.

The Effectiveness Index (E.I.) that has an impact on students' learning progress resulting from the computational thinking skill development activities based on STEM competency-based learning is shown in table 2.

Table 2. The Effectiveness Index (E.I.) of the computational thinking skill development activities based on STEM competency-based learning

Number of students	Full points	Pre-test' score	Post-test' score	Effectiveness Index	Percentage
14	40	132	413	0.66	66

Table 2 shows the Effectiveness Index (E.I.) of the computational thinking skill development activities based on STEM competency-based learning is 0.66, accounting for

66%. This means that the Effectiveness Index points out that students' learning process upon the computational thinking skill development activities based on STEM competency-based learning is high learning progress.

3.3 The results of the computational thinking skill with the computational thinking skill development activities.

The results of the computational thinking skill development among the students majoring in Learning Management Innovation, Computer, with the threshold of 70% is shown in table 3.

Table 3. shows the analysis of the development of computational thinking skill competency among the students majoring in Learning Management Innovation, Computer Science, with the threshold of 70%

Test	n	Full points	$\bar{X}$	S.D.	Percentage	*t*
Post-test	14	20	16.88	1.73	84.40	6.24*

*The *t* value has a statistical significance of .05.

Table 3 shows the analysis of the development of computational thinking skill competency among the students majoring in Learning Management Innovation, Computer, with the threshold of 70%. The mean is 16.88. The standard deviation is 1.73, accounting for 84.40%, which is above the threshold of 70%. The *t* value is 6.24. In other words, the competency assessment of computational thinking skills among the students majoring in Learning Management Innovation, Computer, is above the threshold of 70%, with a statistical significance of .05.

3.4 The results of students' satisfaction with the computational thinking skill development activities.

The results of students' satisfaction with the computational thinking skill development activities based on STEM competency-based learning is shown in table 4.

Table 4. The students' satisfaction with the computational thinking skill development activities based on STEM competency-based learning

Items	$\bar{X}$	S.D.	Satisfactory level
1. Computational thinking skills	4.67	0.49	Highest
2. STEM competency-based learning	4.63	0.54	Highest
3. The impacts of the activities on the students	4.47	0.53	High
Total	4.61	0.52	Highest

Table 4 shows that the students' satisfaction with the computational thinking skill development activities based on STEM competency-based learning is the highest

level ($\bar{X}$ = 4.61, S.D.= 0.52). The activity with the highest mean is computational thinking skill development activities, with the highest level ($\bar{X}$ = 4.67, S.D.= 0.49), followed by STEM competency-based learning, with the highest level ($\bar{X}$ = 4.63, S.D.= 0.54), and the impacts of the activities on the students with high level ($\bar{X}$ = 4.47, S.D.= 0.53).

4. Conclusion and discussion

4.1 The results of the computational thinking skill development activities based on STEM competency-based learning are as follows.

The 18-weeks plan for the development of computational thinking skills based on STEM competency-based learning is implemented, with eight lessons in order to fulfill the course's objectives, based on five STEM education steps is approved by the three experts, with high level ($\bar{X}$ = 4.42, S.D.=0.50). The activities are divided into three steps; step 1 introduction to the course, step 2 learning process and step 3 competency assessment and conclusion. According to Unyaparn Sinlapaninman (2022); Unyaparn Sinlapaninman and Nakintorn Pattanachai (2022) proposed that activities that reflect learning allow students to reflect on their own thoughts, beliefs, attitudes, and actions by looking for reasons to support create understanding of learning, this leads to greater awareness and value of learning experiences. The approaches result from an interdisciplinary integration, which is an integration between Science (S), Technology (T), Engineering (E), Mathematics (M), which is conducive to students' comprehensive development in accordance with the development of human potential in the 21st century: thinking skill based on the concept to design the curriculum, which corresponds to Bybee, R. (2010) and Thibaut, et al. (2018). The research integrated STEM education: A systematic review of instructional practices in secondary education, with five principles: integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning and cooperative learning. In addition, the work contributes to many aspects and the application of STEM and possibilities to explain integrated STEM education. Bryan et al and Tripon, C. define integrated STEM education as the education that is central to problems, inquiry, teamwork, learner-based learning, active learning, assessment, and 21st century skills (Bryan et al., 2015; Tripon, C.,2022).

4.2 The Effectiveness Index (E.I.) of the computational thinking skill development activities based on STEM competency-based learning.

The Effectiveness Index is 0.66, accounting for 66%, meaning that the students' learning is high learning progress. The computational thinking skill development activities based on STEM competency-based learning is an interdisciplinary integration, including science (S), technology (T), engineering (E), and mathematics (M) is conducive

to students' comprehensive development in accordance with the development of human potential in the 21st century: Thinking skill, resulting in students being more interested in studying, which corresponds to the research by Theerachai Aiamphong, et al. (2021). They conduct a research on the development activities based on STEM education in geometric transformation for students in Mattayom 2 (Grade 8), with the results of the STEM education-based development activities are that 1) the development activities based on STEM education in geometric transformation for students in Mattayom 2 (Grade 8) has the score of 85.95/82.86 and 2) the Effectiveness Index of the development activities based on STEM education in geometric transformation for students in Mattayom 2 (Grade 8) is 0.67, accounting for 67%. According to the definitions, the students' learning is high learning progress.

4.3 The results of the computational thinking skill competency of the students in the Department of Learning Management Innovation, Computer, after the learning process, compared to the threshold of 70%.

The results of the computational thinking skill competency of the students in Learning Management Innovation, Computer, after the learning process, compared to the threshold of 70% reveal that the mean is 16.88. The standard deviation is 1.73, accounting for 84.40%. Compared to the threshold of 70%, the *t* value is 6.24. Therefore, the computational thinking skill competency of the students in the Department of Learning Management Innovation, Compute, after the learning process is higher than the threshold of 70%, with a statistical significance of .05. As the learning management applied to the students' learning corresponds to the curriculum. The teacher prepare sources of information for the students, which facilitates their self-study and subsequently equip them with problem-solving skills. As a consequence, the students experience thinking and team-working process students, enabling them to brainstorm to come up with solutions. The approaches result in the students' improved computational thinking skills, which corresponds to a study by Supamas Sankok and Urit Charoen-in (2022) on the problem-based learning activities integrated with lessons on websites to develop Mattayom 4 (Grade 10) students' computational thinking skills, with the results of the study reveal that the mean of the students' computational thinking skills is 27.88 out of 32, accounting for 87.13. Among all the students, 34 of them are in the Excellent level, higher than the required 75%, with a statistical significance of .01.

4.4 The results of the students' satisfaction with the computational thinking skill development activities based on STEM competency-based learning.

The mean of the students' satisfaction with the computational thinking skill development activities based on STEM competency-based learning is the highest level ($\bar{X}$= 4.61, S.D.= 0.52). The activity with the highest mean is computational thinking skill,

with the highest level ($\bar{X}$ = 4.67, S.D.= 0.49), followed by STEM competency-based learning, with the highest level ($\bar{X}$ = 4.63, S.D.= 0.54) and the impacts of the activities on the students with high level ($\bar{X}$ = 4.47, S.D.= 0.53), respectively. With the computational thinking skill development activities based on STEM competency-based learning, the students' computational thinking skills, including decomposition, pattern recognition, abstraction, and algorithm have improved, which correspond to Duangjai Showtale,et al. (2023). They conduct research on the results of online learning management based on the integration of STEM education into engineering thinking, which has an impact on innovative thinking skills among the students in Mattayom 1, Wat Phrasrimahadhat Secondary Demonstration School, Phranakhon Rajabhat University with the reveals that the students' satisfaction with the online curriculum based on the integration of STEM education into engineering thinking, with the highest level ($\bar{X}$ = 4.51, S.D.= 0.44).

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