Implementation of a Curriculum to Enhance Learning Management Competency in Computational Thinking for the Lower Secondary Teachers

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Abstract

Teaching computational thinking develops students in analytical thinking, systematic thinking, step by step reasoning to solve problems, applicable to real-life problems, and can be integrated across a wide range of disciplines, combining knowledge to create works and extend knowledge to other subjects. The objective of this study was to examine the outcomes of a curriculum to enhance learning management competency in computational thinking for lower secondary teachers. The samples were 4 teachers selected by purposive sampling, and 123 grade 8 students selected by the criterion of 70% from private schools under Mahasarakham Provincial Education Office, Office of the Private Education Commission, Thailand. The instruments for the lower secondary teachers were; 1) a test to measure knowledge and understanding of teachers' computational thinking learning management, 2) an assessment form for learning activity design ability, and 3) an observational form of learning management ability, while a computational thinking ability test was employed to the students. The data were analyzed by mean, percentage, standard deviation, and the Wilcoxon signed rank test. The results were; 1) the teachers after the workshop had higher knowledge and understanding of computational thinking learning management than before the workshop; 2) the teachers were able to design learning management that promotes computational thinking at a high level; 3) the teachers were able to provide learning management that promotes computational thinking: overall, the average was good; and 4) the students' computational thinking ability after learning was higher than before learning at a statistical level of .05.

Keywords: learning management competency, computational thinking, lower secondary teachers

1. Introduction

Learning management in the 21st century is an era in which people will face rapid, drastic, twisted, and unexpected changes. People in the modern world, therefore need to be highly skilled in learning and adapting. Teachers are regarded as an important force in driving education, responsible for learning management to develop students to be quality and up to date with changes. They must be knowledgeable, able to manage to learn, have up-to-date knowledge, and broadness, know the world, and keep pace with advances in science and technology and the changes that occur all around (Chumchit, 2007). For teachers' learning management competencies, teachers must be able to integrate learning within and between subject groups in line with real life, have learning designs that are suitable for learners, prepare systematic learning plans, provide hands-on learning activities to enable students to think, do and solve problems, use a variety of materials and learning resources to promote learning, and assess and improve effective learning management. For the development of teacher competency must be considered from the changing social context, focusing on teachers to develop themselves to have higher competencies, leading to effective performance, aiming for the greatest benefit to the development of learning management and the quality of learners is important (Office of the Education Council, 2008).

Education management in Thailand today has changed in many aspects. The curriculum in the 21st century aims to develop people with the characteristics of knowledge, learning skills, thinking skills, and life skills. The Ministry of Education has an important and urgent policy to improve the Basic Education Core Curriculum (B.E. 2551) in the learning areas of mathematics, science, and technology (Bureau of Academic and Educational Standards, 2018). The policy and focus of the fiscal year 2020 aimed to provide teaching and learning that was in line with the national strategy, especially the urgent policy on preparing people for the 21st century. The Ministry of Education has therefore announced a policy focused on teaching and learning the rational and step-by-step thinking skills (coding) of students from kindergarten to vocational levels and developing teachers' expertise in teaching English and computer languages (Ministry of Education, 2019). In the age of digital and technology that grows rapidly and plays a role in everyone's daily lives, learning to code (coding) is therefore necessary for the new generation of youngsters as well as entrepreneurs, and to keep pace with the world, coding is therefore a necessity in Thai education (Deprasert, 2019). Coding is now included in the basic teaching curriculum for schools across the country (Institute for the Promotion of Teaching Science and Technology, 2017).

The most important element of learning to code is teaching computational thinking, which will help develop children's critical thinking process, thinking systematically, and reasoning step by step to solve problems. Computational thinking is the science of learning methods used in problem solving, system design, and analytical thinking, analyzing the behavior of things based on the basic concepts of computation by using mathematical methods to help find answers, analyze data, and create solutions step by step (algorithms). Learners can apply computational thinking skills to solve real-life problems, integrate with various disciplines, combine knowledge to create works, and extend knowledge to other subjects (Barr & Stephenson, 2011; Csizmadia et al., 2015; Lockwood & Mooney, 2018; Wing, 2006; and the Institute for the Promotion of Teaching Science and Technology, 2017).

Teachers' learning management competencies consist of core competencies and line competencies; in particular, teachers must have line competencies in learning management, which is their main function. In learning management, teachers must have five competencies, namely: 1) the ability to design learning activities; 2) the ability to create learning management plans; 3) the ability to organize learning activities; 4) the ability to use technology and media in learning management; and 5) the ability to measure and evaluate results (Office of the Education Council, 2008; Wangmeejongmee & Naipat, 2017; Office of the Basic Education Commission, 2010; The Secretariat of the Teachers' Council of Thailand, 2005; Panich Phlinchai, 2016; Warinin, 2014; Ministry of Education, 2017; and Parson, 1996).

The researcher, as a supervisor, has supervised and monitored the educational management results of private schools under Mahasarakham Provincial Education Office and found that the learning management according to the school curriculum of teachers still lacked knowledge, understanding, and skills in learning management, had no sufficient knowledge of learning management and learning process design in relation to learning standards and curriculum indicators, and teachers did not analyze learning standards and core curriculum indicators according to the Basic Education Core Curriculum 2008 and were unable to design self-learning management. Most teachers teach based on textbooks, explaining knowledge from textbooks to students with activities based on exercises in textbooks rather than having student practice critical thinking and problem-solving skills. The students participated in the learning activities relatively little, and the design of learning measurement and evaluation was inconsistent with the teaching and learning activities (Mahasarakham Provincial Education Office, 2019).

For the reasons mentioned above, the researcher has developed a curriculum to enhance learning management competency for lower secondary school teachers that promotes computational thinking so that learners can create new knowledge using various thinking approaches, applying and modifying learning methods by problem-solving and problem-based learning based on constructivist theories. In this study, the implementation outcomes of the curriculum will be presented.

2. Conceptual Framework of the Curriculum

The conceptual framework of the curriculum to enhance learning management competency in computational thinking for the lower secondary teachers composed of can be illustrated in Figure 1.

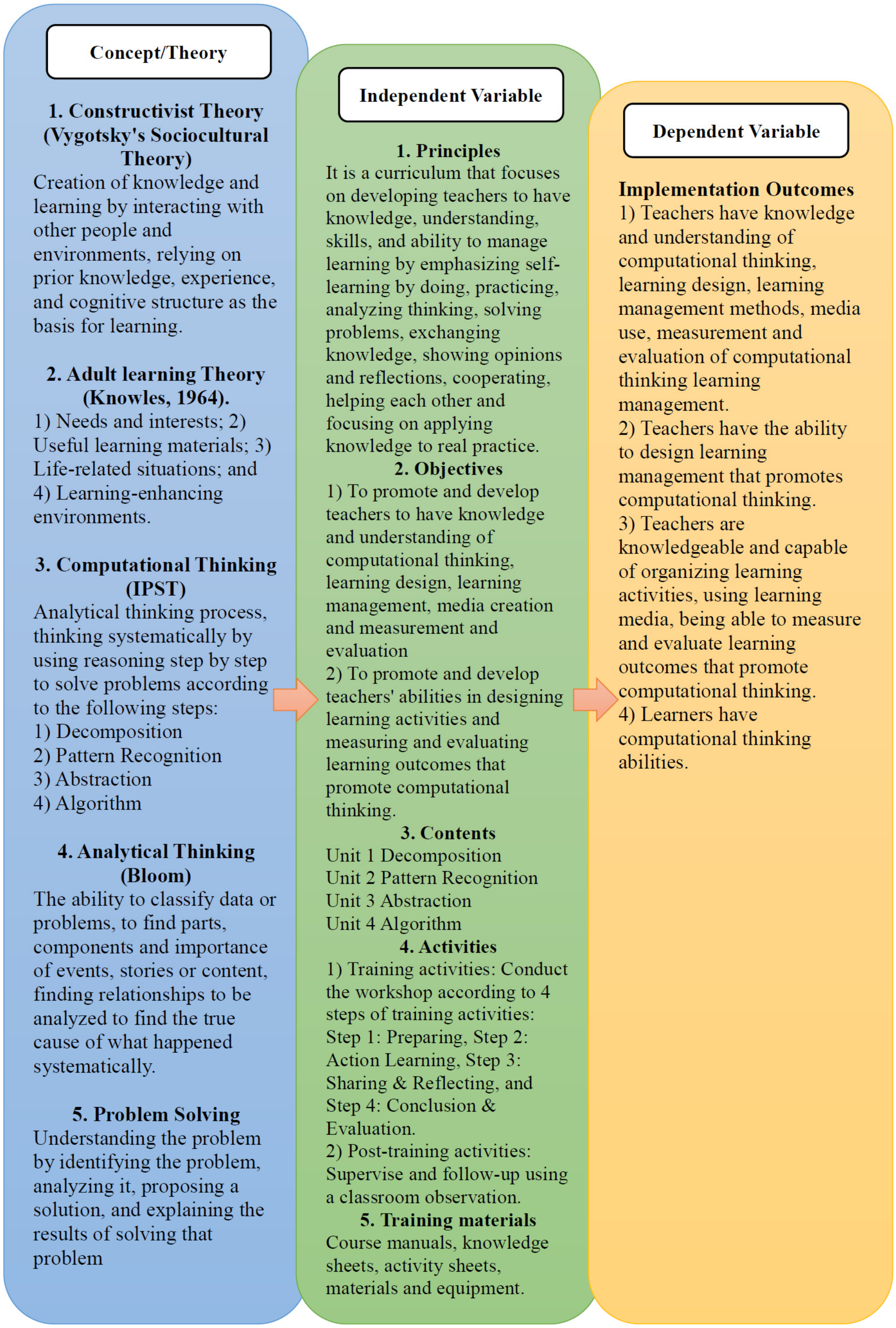

Figure 1. The Conceptual Framework of the Curriculum to Enhance Learning Management Competency in Computational Thinking for the Lower Secondary Teachers

3. Method

3.1 Participants

The participants were 4 teachers who had a minimum of three years of teaching experience in science and technology, selected by purposive sampling from 14 teachers from 7 private schools under the Mahasarakham Provincial Education Office, Office of the Private Education Commission, Thailand. Moreover, 123 grade 8 students were selected by the criterion of 70% of each class: 65 of 96, 34 of 52, 15 of 24, and 9 of 13. The study took 2 days of the workshop (14 hours) and 12 weeks for learning management in the classrooms during the second semester of the academic year 2021.

3.2 Instruments

The research instruments were: 1) a test to measure knowledge and understanding of teachers' computational thinking in learning management with 30 multiple-choice items for pre-test and post-test (rtt=0.95); 2) an assessment form for learning activity design ability with 20 items on a 5-point Likert scale (the highest level of appropriateness: $\bar{x}$=4.54, S.D.=0.55); 3) an observational form of learning management ability with 18 items on a 5-point Likert scale (a high level of appropriateness: $\bar{x}$=4.43, S.D.=0.53); and 4) a computational thinking ability test for the students with 30 multiple choice items for pre-test and post-test (rtt=0.98). The instruments' quality was verified by 5 experts whose expertise was in the fields of curriculum, measurement, and evaluation, training, and learning management.

3.3 Data Collection

During the 2nd semester of the academic year 2021, the data collection was divided into 2 phases. In Phase 1, the 4 teachers attended a workshop held by the researchers to learn and apply principles and theories relevant to the curriculum: adult learning and constructivism. The workshop was composed of 4 steps including, Step 1: Preparing, Step 2: Action Learning, Step 3: Sharing & Reflecting, and Step 4: Conclusion & Evaluation. During the workshop, their learning management was observed and assessed for the first time. This took 14 hours out of 2 days. In Phase 2, the teachers were assigned to implement the curriculum in the classroom after the workshop. During the 12 weeks of learning management, they were observed, reflected on, and coached by their peers and the experts (the second observation). Both offline and online follow-up and supervision were closely carried out.

3.4 Data Analysis

In order to analyze the data from the test to measure teachers' knowledge and understanding of computational thinking in learning management, the assessment form for learning activity design ability, and the observational form of learning management ability, the researchers employed the use of the Statistical Package for Social Sciences (SPSS): mean, percentage, and standard deviation. Furthermore, the Wilcoxon signed rank test was applied to examine the difference between the pre-test and post-test scores of the students' computational thinking ability.

4. Results

The curriculum to enhance learning management competency in computational thinking for the lower secondary teachers composed of 4 elements as shown in Figure 2.

The form of the training activities was a workshop where teachers were trained according to the content of units 1-4. The activities consisted of activities to clarify the objectives of training, pre-tests, training activities, and post-tests. There were four steps to the training activities, as follows: Step 1: Preparing—the trainers motivate learning, arouse interest in participants using game activities, and use Q&A to check and review knowledge and understanding of the training content. They discuss and reflect on the existing knowledge and understanding. Step 2: Action Learning—the trainers provide knowledge by allowing the participants to understand the content issues learned, practice activities according to each learning unit by designing and planning the activities in a sequence of steps systematically, and do self-directed activities. Step 3: Sharing & Reflecting—the participants participate in discussions, present the results of the activities, share knowledge, and reflect on the issues learned from the activities. And Step 4: Conclusion & Evaluation—the participants review and build knowledge by comparing their initial ideas with those at the end of the lesson, summarizing knowledge for themselves, and the trainers evaluate the results after the lesson at the end of each unit.

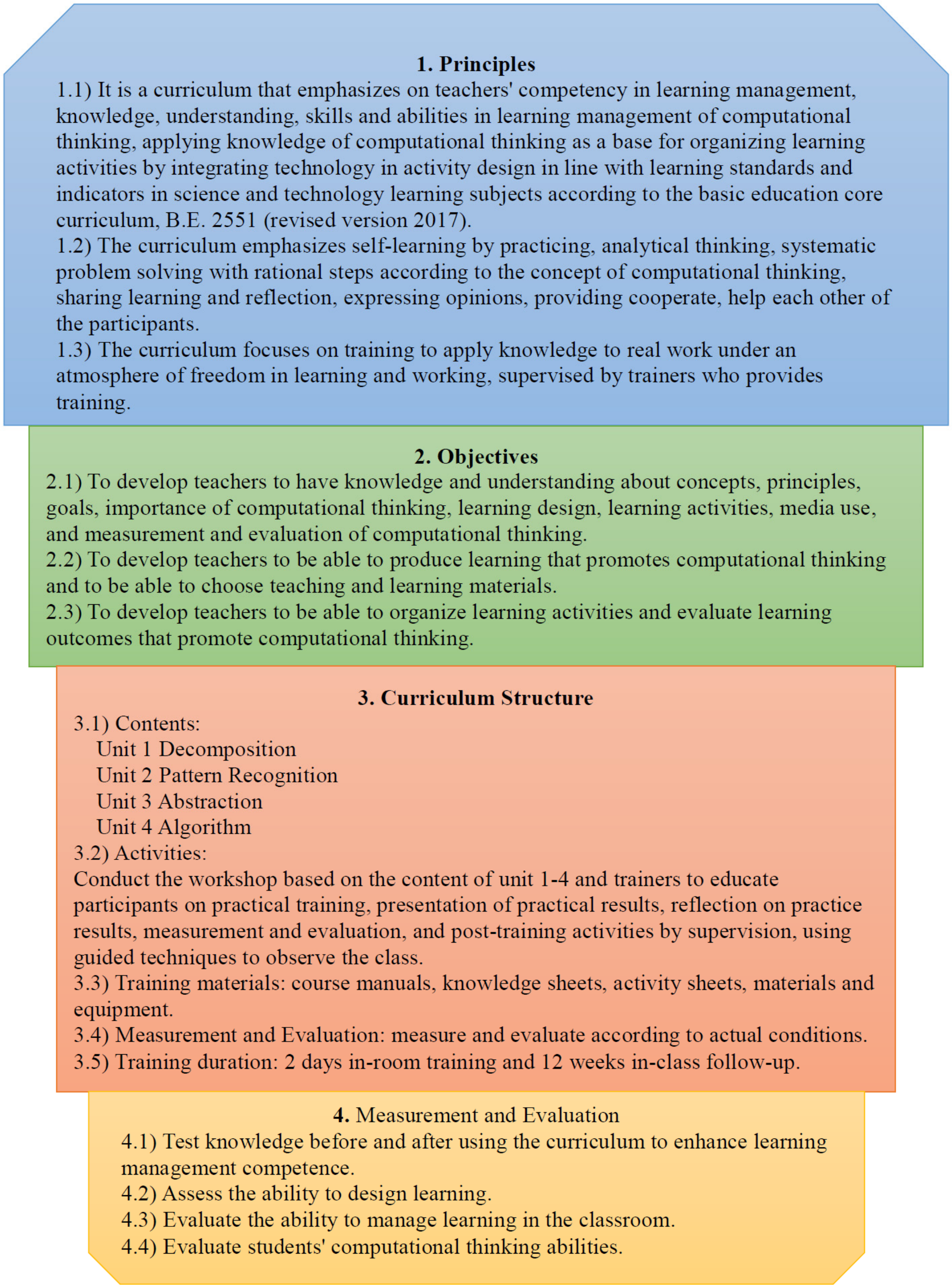

Figure 2. The Elements of the Curriculum to Enhance Learning Management Competency in Computational Thinking for the Lower Secondary Teachers

4.1 Knowledge and Understanding of Teachers' Computational Thinking Learning Management

The participants (4 teachers) took the pre-test and post-test with 30 multiple choice items to measure their knowledge and understanding of computational thinking learning management, and the comparison of test results before and after the workshop can be illustrated in Table 1.

Table 1. Comparison of Knowledge and Understanding of Teachers' Computational Thinking Learning Management before and after the Workshop

No.	Pre-test Score (30)	Post-test Score (30)	Mean difference
1	17	28	11.00
2	13	26	13.00
3	11	22	11.00
4	14	23	9.00
Total score	**55**	**99**	**44.00**
$\bar{x}$	**13.75**	**24.75**	**11.00**
S.D.	**2.50**	**2.75**	**1.63**
Percentage	**45.83**	**82.50**	**36.67**

As seen in Table 1, while the pre-test mean score was 13.75 (S.D.=2.50), the post-test mean score was 24.75 (S.D.=2.75), The mean difference between the pre-test score and the post-test score was 11.00 (S.D.=0.25; and 36.67%). Therefore, this indicated that the teachers after the workshop had higher knowledge and understanding of computational thinking learning management than before the workshop.

4.2 Teachers' Ability to Design Learning Management That Promotes Computational Thinking

Table 2. The Teachers' Learning Activity Design Ability That Promotes Computational Thinking

Items	Results		
	Mean	S.D.	Interpretation
Learning Unit			
1. Learning standards, indicators, key competencies of learners are appropriately linked.	4.50	0.57	high
2. Concepts, subject matter, and learning standards/indicators are consistent.	4.50	0.57	high
3. Learning activities are consistent with learning subject matter, learning standards and indicators.	4.25	0.50	high
4. Learning activities cover the development of learners to have knowledge and ability to think computationally.	4.00	0.00	high
5. Learning activities can lead learners to create tasks.	4.25	0.50	high
6. The assessment was consistent with learning standards and the Computational Thinking Ability indicators.	4.00	0.00	high
7. Evaluation criteria can reflect learner quality according to standards/indicators.	4.25	0.50	high
8. The learning materials are appropriate enough for each activity.	4.50	0.57	high
9. The timing of the learning unit is appropriate for the learning activities.	4.50	0.57	high
10. Learning units can be used to manage learning for students.	4.50	0.57	high
Lesson plan			
11. The lesson plans are consistent with the specified learning unit.	4.50	0.57	high
12. The lesson plans have all components related to each other.	4.25	0.50	high
13. The lesson plans have appropriate assignments/tasks.	4.25	0.50	high
14. The lesson plans determine the appropriate materials, equipment, media and learning resources in line with the learning content and learning activities.	3.75	0.50	high
15. Learning activities are suitable for the learners and their level.	4.00	0.00	high
16. Learning activities are diverse and practical.	4.25	0.50	high
17. Learning activities promote the students' computational thinking.	4.25	0.50	high
18. Activities focus on learners to learn from real practices.	3.75	0.50	high
19. Measurement and evaluation are consistent with the learning standard/indicators.	4.00	0.81	high
20. A wide range of learners' computational thinking abilities were assessed.	4.25	0.50	high
Total Score	**4.22**	**0.46**	**high**

Note. 4.51 – 5.00 = the highest 3.51 – 4.50 = a high 2.51 – 3.50 = a moderate
1.51 – 2.50 = a low 1.00 – 1.50 = the lowest

The assessment form with 20 items was used to assess the participants' learning activity design ability and the findings can be seen in Table 2.

As shown in Table 2, the mean score of learning activity design ability that promotes computational thinking in every item was at a high level (3.75-4.50). The total score from this instrument was 4.22 (S.D.=0.46). Thus, the teachers had the learning activity design ability at a high level.

4.3 Teachers' Ability to Provide Learning Management That Promotes Computational Thinking

The findings from the observational form of learning management ability with 18 items used for the classroom observation 2 rounds can be presented in Table 3.

Overall, the participants' ability to provide learning management that promotes computational thinking was at a good level, according to Table 3 ($\bar{x}$=3.70, S.D.=0.71). When considering each round, the mean score of the first round was 3.10 (S.D.=0.47). Moreover, almost every item of it was at a fair level ($\bar{x}$=2.58-3.33) except Item 1, which was at a very good level ($\bar{x}$=4.83, S.D.=0.39). For the second round, the mean score increased to a good level ($\bar{x}$=4.30, S.D.=0.45). Apparently, every item in the second round was higher than the first.

In addition, the observations found from the experimental curriculum in the training room showed that at first, the teachers were anxious about participating in activities, did not dare to express their opinions, and waited to follow the trainers' instructions, which meant the trainers often had to encourage participants to express their thoughts by using leading questions. In Unit 1 Decomposition, the trainees performed rigorous activities. When entering the preparation phase of the training that the trainers had planned, the participants played games, watched video media and video clips, and found answers to everyday problems that the trainers presented, which relieved their anxiety and made them eager to find answers from practice, both from playing games and performing activities. Participants talked with their fellow teachers, exchanged ideas, and received help from their fellow teachers, making them ready to learn and showing their potential very well. However, due to the small number of participants affecting the process of discussion and the exchange of knowledge, which was limited to only 4 people, there was only 1 group to exchange knowledge, which made it possible to express opinions from previous experiences of teachers that were not diverse. In each activity, the participants participated in every step of the activity, and exchanges of knowledge and opinions were inserted into the activity process. And when problems arose, the participants would help each other propose guidelines and find solutions together in the group.

Furthermore, the results of the observation of the teacher's learning management in the classroom were revealed. The teachers managed the learning based on the designed learning management plans. While the researcher or the observers recorded the activities that occurred in the class, it was found that in the early stages, teachers used questions to encourage students to answer all the time. They did not express their ideas or explain their answers because they were not familiar with the teaching methods and were not confident, afraid that the answer would be wrong, and there were strangers sitting in the classroom, so they did not dare to express their opinions. The students must be encouraged by using leading questions at all times. Some groups of students still did not sequence the events that had happened as well as they should have. The groups that thought outside the box were caused by the advice of the teacher; they still couldn't think for themselves. The teacher set the framework for work, which the students were not allowed to do independently. In subsequent activities, when the teacher initiated the activity according to the lesson plan, the students participated and cooperated very well. Learning management could continue smoothly; students could express their rationale for the activity and then summarize the concepts to connect them to knowledge. Students were more assertive and learned happily.

From discussions with teachers and co-observers, the results of learning management could be reflected as follows:

"In group work, students should divide their responsibilities so everyone can participate in the activity." "Students take pride in the group's work and love working with others" (Observer).

"Group presentations, if students were to use a larger and clearer medium, would be great since students sitting at the back could not see what their peers were presenting" (co-observer).

"I want friends to do activities together; everyone plays a lot of fun games." (Students).

Students cooperate and are interested in activities as well. For people who don't like to express their opinions when they have done an activity, instead invite friends to do activities together. People who don't like to talk have the opportunity to chat with friends while doing activities. Students are happy and fun to learn, as can be seen from their facial expressions, their voices, their conversations, and their constant laughter. Sometimes there are complaints when peers disagree. (Teachers)

Table 3. The Teachers' Learning Management Ability That Promotes Computational Thinking

Items	Training Room Observation Round 1			Classroom Observation Round 2		
	Mean	**S.D.**	**Interpretation**	**Mean**	**S.D.**	**Interpretation**
1. The teacher had a learning management plan that promoted computational thinking.	4.83	0.39	Very good	4.92	0.29	Very good
2. The teacher proceeded the instruction in a sequential manner according to the lesson plan.	3.25	0.45	Fair	4.42	0.51	Good
3. The teacher organized learning that encouraged learners to think in parts.	3.33	0.65	Fair	4.42	0.51	Good
4. The teacher organized learning that encouraged learners to think in patterns.	3.08	0.51	Fair	4.25	0.45	Good
5. The teacher organized learning that encouraged learners to think abstractly.	2.83	0.58	Fair	4.08	0.29	Good
6. The teacher organized learning that encouraged learners to think in steps (algorithms).	2.92	0.67	Fair	4.17	0.39	Good
7. The teacher used questions to encourage students to practice computational thinking.	3.08	0.51	Fair	4.50	0.52	Good
8. The teacher associated prior knowledge or experiences with the lessons or content being taught.	3.00	0.43	Fair	4.42	0.51	Good
9. The teacher had a variety of ways to encourage students to practice computational thinking.	3.00	0.43	Fair	4.08	0.29	Good
10. The teacher organized activities for students to practice computational thinking.	3.08	0.51	Fair	4.33	0.49	Good
11. The teacher had a variety of computational thinking assessment methods.	2.67	0.49	Fair	3.83	0.58	Good
12. Learners reacted by answering questions and expressing themselves appropriately.	3.08	0.29	Fair	4.25	0.45	Good
13. Learners had a discussion and exchange of ideas about the content they were learning.	3.00	0.60	Fair	4.50	0.52	Good
14. Learners were free to think and work.	3.17	0.58	Fair	4.42	0.51	Good
15. Learners were able to separate issues from problem situations and propose solutions.	3.00	0.60	Fair	4.33	0.49	Good
16. Learners practiced analyzing and solving problems from the activities in the lesson.	3.00	0.74	Fair	4.25	0.45	Good
17. Students expressed their opinions, exchanged discussions with friends before summarizing knowledge and answering questions in the lesson.	2.92	0.51	Fair	4.50	0.52	Good
18. Learners could apply the knowledge learned in their daily lives.	2.58	0.51	Fair	3.75	0.45	Good
Mean	**3.10**	**0.47**	**Fair**	**4.30**	**0.45**	**Good**
Overall				**3.70**	**0.71**	**Good**

Note. 4.51– 5.00 = Very good 3.51 – 4.50 = Good 2.51 – 3.50 = Fair
1.51 – 2.50 = Should be improved 1.00 – 1.50 = Must be improved

4.4 The Students' Computational Thinking Ability

The participants (123 students) took the pre-test and post-test with 30 multiple-choice items to measure their computational thinking ability, and the comparison of test results before and after learning through the curriculum can be demonstrated in Table 4.

Table 4. Comparison of Students' Computational Thinking Ability before and after Learning

Test	n	Full score	Mean	S.D.	Wilcoxon Value	Wilcoxon (1-tailed)
Pre-test	123	30	16.66	4.04	9.64	.000*
Post-test	123	30	28.72	3.79		

Note. *p<.05

As demonstrated in Table 4, the pre-test mean score was 16.66 (S.D.=4.04) while the post-test mean score was 28.72 (S.D.=3.79). The Wilcoxon value was 9.64. Therefore, the average score of students' computational thinking ability after learning was significantly higher than before learning at the .05 level. It can be easily demonstrated by Bar Chart 1.

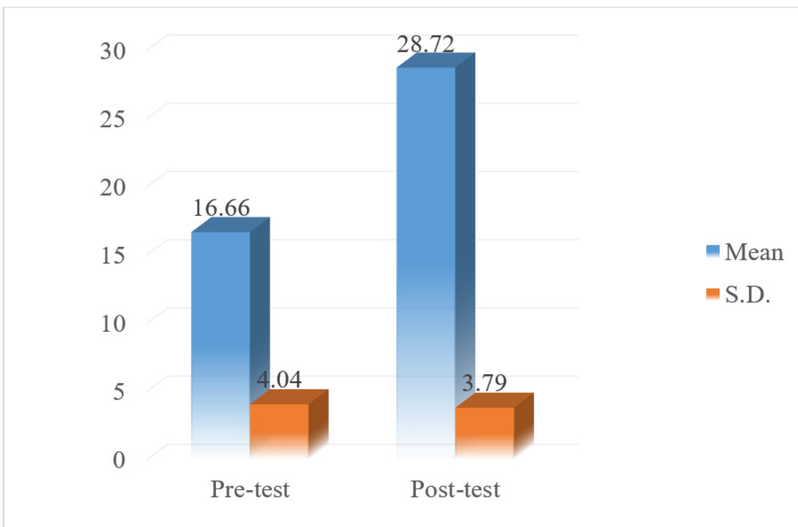

Chart 1. The Students' Computational Thinking Ability before and after Learning

5. Discussion

In addition to the above, the researcher developed the curriculum to enhance learning management competency in computational thinking for the lower secondary teachers according to the R&D process. The curriculum with 4 elements was verified and rated as having a high level of appropriateness by experts ($\bar{x}$=4.32, S.D.=0.67). The implementation outcomes indicated that the curriculum was effective in increasing teachers' learning management competency in computational thinking as well as students' computational thinking abilities. The findings can be discussed as follows:

1) The teachers had a higher level of knowledge and understanding of learning management that promoted computational thinking. This was because the researcher had designed the curriculum with a systematic curriculum development process that truly corresponded to the needs and interests of the trainees. The content of the training activities in the curriculum was what the participants wanted to study, which consisted of content according to the elements of computational thinking in all 4 areas. And when the training was completed, the participants could actually apply the knowledge and experience gained in the classroom. In addition, the participants learned by doing by themselves and sharing what they learned from doing and discovering in a friendly training atmosphere where everyone was free to express themselves. There was reflection on the results of the practice, resulting in quality development according to the desired goals. This was in line with the concept of constructivist theory (Laowreandee, 2009; and Vella, 1995), which stated that knowledge and the method of acquiring knowledge by creating

self-knowledge, interacting with other people and the environment, and learning were more effective if they were learned by doing rather than by taking. This was consistent with the research of Baytak, Land and Smith (2011), Rodríguez del Rey et al. (2021), and Knie, Standl and Schwarzer (2022) who had conducted studies on the application of computational thinking to training courses. The results showed that the implementation of computational concepts in the educational curriculum affected the understanding of the principles of computational thinking development. There was a statistically significant difference before and after use at the .05 level and the participants' satisfaction was at a high level.

2) The teachers had overall ability in designing learning management that promote computational thinking at a high level. This was because teachers had learned by doing activities, practicing thinking, and designing learning management in accordance with the Basic Education Curriculum (B.E. 2551) (2017 revised edition). This was the development of the knowledge, skills, characteristics, and abilities of teachers to have competency in managing learning in computational thinking in accordance with the goals set by the curriculum. In addition, the workshop was suitable and consistent between the components of the curriculum and the training activities in terms of content and time. The workshop was to provide knowledge and practice together. This was in line with constructivist theory and the principle of adult learning that learning became more effective when trainees were exposed to hands-on and repetitive practice. Practical training would make the trainees lessons clear and durable. In addition, the participants exchanged knowledge with each other by bringing what they learned to discussions with the trainers, who shared their knowledge and guided them by linking the relationship between what they did not know and what they already knew. Moreover, the experience of the participants was considered a valuable source of knowledge. The different experiences of each adult class member allowed participants to benefit from each other (Knowles, 1975). This was in harmony with the concept of constructivist learning, which holds that learning is an action process involving finding solutions to problems by ourselves through the process of absorbing information. Presenting a variety of information using both techniques and methods would help stimulate the scaling of the intellectual structure (Chaijaroen, 2008). The practical approach to learning rather than learning to memorize according to the teacher differed from the traditional approach to teacher-led learning (Fosnot and Perry, 1996; Glasersfeld, 1991; Wilson, 1996; Cobb, 1994; and Bell, 1993). This was consistent with the research of Conrad (1996), who conducted a quasi-experimental study on grade 5 students using constructivism to develop thinking skills using scientific processes. The results showed that the learners had skills in thinking, including critical thinking and creative thinking. Likewise, Dol (2015) studied the development of animation media by drawing flowcharts for algorithm development. The results showed that the learners' learning achievement after learning was greater than before learning, and that the learners were very satisfied with learning with this type of media.

3) The teachers had the learning management ability that promoted computational thinking at a good level. This was because the researcher conducted the workshop through the training process, causing teachers to learn by doing activities, practicing thinking, and practicing, which led to the development of knowledge, skills, characteristics, and abilities of teachers to achieve competency to manage learning in computational thinking according to the goals set by the curriculum. In addition, teachers' ability to manage learning at a good level was a result of being supervised in the management of learning by trainers and fellow teachers who provided guidance in the form of guided supervision. The teachers reflected on the results of their teaching, guided the teaching of teachers, and finally, teachers were the ones who summarized the results of the recommendations to obtain the main principles to improve teaching and learning management. As a result, learners achieved their objectives in learning management and had higher learning outcomes. This was in line with the concepts of Panlert (2007); Phumi (2006), and Moon (2004), which stated that guidance helped individuals reflect on their abilities to identify areas of need, helping them apply knowledge to work and develop their abilities. Similarly to the principles of adult learning, the learning principles that must be applied in the design and development of competency curricula are that learning becomes more effective when trainees perform repetitive tasks (Stone, 2013). This was in harmony with the studies of Lye and Koh (2014), Bower et al. (2015), and Menolli and Neto (2022), who researched the application of concepts and principles of computational thinking to solve problems in the daily lives of learners by experimenting with practical training for science and mathematics teachers using simulations developed with Python programs. It was found that teachers were more confident in developing their students' computational thinking abilities after participating in the workshop. Learners could gain a greater understanding of the subject matter, and accessible common technologies could help foster computational thinking in everyday life.

4) The computational thinking ability of the students after learning was higher than before at the statistical significance level of .05. This was because the teachers had been trained in the design of learning activities in the content that met the standards and indicators of the curriculum by designing a variety of learning activities in line

with the needs of the learners and organizing learning activities using games, digital media, computers, and smartphones with a focus on the learners. This was consistent with the concept of learning according to the constructivist theory that learning was a hands-on process of finding self-solving solutions through the process of absorbing information. Presenting a variety of information using both techniques and methods would help stimulate the scaling of the intellectual structure (Sumalee Chaijaroen, 2008). This was in line with Wu, 2018, Poolsawas, 2017, Phadung et al., 2018, and Suphaluk (2018), who studied the promotion of computational thinking skills in learners. The results of the study revealed that the learners had different learning outcomes before and after learning at a statistical significance level of .05.

6. Conclusion

The curriculum to enhance learning management competency in computational thinking for the lower secondary teachers had four elements, including principles, objectives, curriculum structure, and measurement and evaluation. The 4 steps of training activities consisting of Step 1: Preparing, Step 2: Action Learning, Step 3: Sharing & Reflecting, and Step 4: Conclusion & Evaluation were conducted during the workshop. Obviously, the curriculum was beneficial to improving teachers' learning management competency in computational thinking, as their higher knowledge and understanding of computational thinking learning management, their learning activity design ability at a high level, and their ability to provide learning management that promotes computational thinking were at a good level, as well as their students' computational thinking ability after learning was significantly higher than before learning, as mentioned above. The objective of this study was therefore achieved: to investigate the outcomes of a curriculum to enhance learning management competency in computational thinking for lower secondary teachers.

7. Recommendation

For implementing the curriculum, the needs of teachers should be studied before using it because it was created to meet the needs of private school teachers under Mahasarakham Provincial Education Office. The contents are in the science and technology learning subject group, where the needs of teachers in each context may be different. Additionally, the duration should be adjusted to be flexible according to the content and the trainee teachers, so that the training process is in line with the needs of the trainees and has continuity in performance. For further studies, a curriculum to enhance learning management competency in computational thinking should be developed in other subject areas with a variety of learning styles to encourage learners to have the skills and processes to solve problems encountered in daily life. Moreover, the outcomes of applying knowledge to the subject content in other learning subjects should be investigated in order to create continuity and develop computational thinking skills.

References

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community?. *Acm Inroads, 2*(1), 48-54. https://doi.org/10.1145/1929887.1929905

Baytak, A., Land, S. M., & Smith, B. K. (2011). Children as Educational Computer Game Designers: An Exploratory Study. *Turkish Online Journal of Educational Technology-TOJET, 10*(4), 84-92.

Bell, B. F. (1993). *Children science, constructivism and learning in science*. Gelong: Deakin University Press.

Bower, M., & others. (2015). Teacher conceptions of computational thinking–implications for policy and practice. *Australian Journal of Education, 3*(5), 1-16.

Bureau of Academic and Educational Standards. (2018). *Supporting documents for key personnel development workshops to create understanding on Applying learning standards and indicators for learning subjects in mathematics, science and geography*. Bangkok: Office of the Basic Education Commission.

Chaijaroen, S. (2008). *Educational Technology: Principles, Theory into Practice*. Khon Kaen: Department of Educational Technology, Faculty of Education, Khon Kaen University.

Chumjit, Y. (2007). *Teachership* (4th ed.). Bangkok: Odeon Store.

Cobb, P. (1994). Constructivism in mathematics and science education. *Educational researcher, 23*, 4-4. https://doi.org/10.3102/0013189X023007004

Conrad, W.H. (1996). A Constructivist - Based Instructional Approach to Help Fifth - Grade Students Improve Selected Elements of Scientific Literacy. *Dissertation Abstracts International, 57*(1), 158-A.

Csizmadia, A., & others. (2015). *Computational thinking-A guide for teachers*. California, United States: Computing At School.

Deprasert, H. (2019). *Coding Skills, Important Skills of the Future*. Bangkok: Kom Chad Luek.

Dol, S. M. (2015). *An Animated Flowchart with Example to Teach the Algorithm Based Courses in Engineering*. New Orleans: Paper presented at the 2015 IEEE Seventh International Conference on Technology for Education (T4E). https://doi.org/10.1109/T4E.2015.3

Fosnot, C. T., & Perry, R. S. (1996). Constructivism: A psychological theory of learning. *Constructivism: Theory, perspectives, and practice, 2*(1), 8-33.

Glasersfeld, E. V. (1991). *An exposition of constructivism: Why some like it radical. In Facets of systems science* (pp. 229-238). US: Springer. https://doi.org/10.1007/978-1-4899-0718-9_14

Institute for the Promotion of Teaching Science and Technology. (2017). *A manual for the basic science curriculum in the science learning group*. (Revised edition 2017) according to the Basic Education Core Curriculum B.E. 2551, elementary level. Bangkok: Institute for the Promotion of Teaching Science and Technology.

Knie, L., Standl, B., & Schwarzer, S. (2022). First experiences of integrating computational thinking into a blended learning in-service training program for STEM teachers. *Computer Applications in Engineering Education, 2*(6), 14-22. https://doi.org/10.1002/cae.22529

Knowles, M. S. (1964). What Do We Know about the Field of Adult Education?. *Adult Education, 14*(2), 67-79.

Knowles, M. (1975). *Self-directed learning: a guide for learners and teachers*. New Jersey: Cambridge Adult Education. https://doi.org/10.1177/0013161X6401400202

Laowreandee, W. (2009). *Models and strategies for learning management to develop thinking skills*. Nakhon Pathom: Silpakorn University.

Lockwood, J., & Mooney, A. (2018). Developing a Computational Thinking Test using Bebras problems. *International Journal of Computer Science Education in Schools, 2*(1), 15-23. https://doi.org/10.21585/ijcses.v2i1.26

Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12?. *Computers in Human Behavior, 41*, 51-61. https://doi.org/10.1016/j.chb.2014.09.012

Mahasarakham Provincial Education Office. (2019). *Report on the results of supervision monitoring the development of private school education quality in Maha Sarakham Province*. Maha Sarakham: Mahasarakham Provincial Education Office.

Menolli, A., & Neto, J. C. (2022). Computational thinking in computer science teacher training courses in Brazil: A survey and a research roadmap. *Education and Information Technologies, 27*(2), 2099-2135. https://doi.org/10.1007/s10639-021-10667-0

Ministry of Education. (2019). *Indicators and core learning subjects in the science learning subject group according to the basic education core curriculum*. Bangkok: Agricultural Cooperative Assembly Printing House.

Moon, J. A. (2004). *A Handbook of Reflective and Experiential Learning: Theory and Practice*. London: Routledge Falmer.

Office of the Basic Education Commission. (2010). *Teacher Competency Evaluation Handbook*. Bangkok: Agricultural Cooperative Assembly of Thailand Printing House.

Office of the Education Council. (2008). *Shortage of teachers, faculty members and educational personnel and proposed solutions*. Bangkok: Prigwan Graphic.

Panich Phlinchai, J. (2016). The Development of Learning Management Competencies in the 21st Century of Undergraduate Students. Faculty of Education Naresuan University. *Journal of Humanities and Social Sciences, 22*(2), 25-37.

Panlert, C. (2007). *The development of a process for enhancing the guidance capacity of mentors by using experiential learning in school-based training*. Doctoral dissertation in Education, Department of Curriculum and Teaching, Graduate School, Chulalongkorn University.

Parson, C. (1996). *Developing New Skills in Teachers*. London: Red Books.

Phadung, M., Namburi, S., Doemrat, P., & Latakeke, I. (2018). *Research report on promoting logical thinking skills* *by writing a robot control program for high school students in the southern border provinces*. Yala: Yala Rajabhat University.

Poolsawas, B. (2016). Interactive Design and Game Development. *Journal of Information Science and Technology, 6*(2 (Jul- Dec).

Poomi, M. (2006). *The science of change for success*. Bangkok: DMG.

Rodríguez del Rey, Y. A., & others. (2021). Developing computational thinking with a module of solved problems. *Computer Applications in Engineering Education, 29*(3), 506-516. https://doi.org/10.1002/cae.22214

Stone, R. J. (2013). *Managing human resources* (4th ed.). Australia: John Wiley.

Suphaluk, S. (2018). *Cloud based learning system based on reverse engineering concepts and peer learning techniques to promote cognitive thinking.* Doctoral dissertation in Education, Educational Technology and Communication Program, Graduate School, Chulalongkorn University.

Vella, J. (1995). *Training through Dialogue. Promoting Effective Learning and Change with Adults*. San Francisco: Jossey-Bass.

Wangmeejongmee, C., & Naipat, O. (2017). Competency of Thai teachers in the 21st century: adjust learning, change competency. *Journal of HR intelligence, 12*(2), 47-63.

Warinin, N. (2014). The Development Model of Teacher Learning Management Competency for Schools under Kamphaeng Phet Primary Educational Service Area Office 2. *Veridian E-Journal, 7*(2), 1-13.

Wilson, S. M. Z. (1996). The Self-Empowerment Index: A Measure of Internally and Externally Teacher Autonomy. *Educational and Psychological Measurement, 12*(8), 53.

Wing, J. M. (2006). Computational thinking. *Communications of the Acm, 49*(3), 33-35. https://doi.org/10.1145/1118178.1118215

Wu, M. L. (2018). Educational Game Design as Gateway for Operationalizing Computational Thinking Skills among Middle School Students. *International Education Studies, 11*(4), 15-28. https://doi.org/10.5539/ies.v11n4p15

The Secretariat of the Teachers' Council of Thailand. (2005). *Educational Professional Standards*. Bangkok: The Secretariat of the Teachers' Council of Thailand.