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Development of Mathematics Learning Activities by Using Inquiry Process with Creative Problem-solving (CPS) to Promote Computational Thinking Skills in Matthayomsuksa 2 Students

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Abstract: - *Computational thinking skills are essential for today's learners. The learning management model using the inquiry process with Creative Problem-solving (CPS) can be used to develop computational thinking skills, creative thinking, analytical thinking, and problem-solving in a systematic manner for students. The purpose of this research was to develop the mathematics learning activities using a creative problem-solving process to promote computational thinking skills of grade 8 students in a study about of efficiency to mathematics learning activities according to the specified criteria of 70/70, comparison to computational thinking skills, and comparison to achievement according to criteria of 70% with grade 8 students of 41 people in Mahasarakham University Demonstration School. The data came from learning management plans of 7 lessons, and the achievement test to data analysis was analyzed by percentage, mean, standard deviation, and t-test. The study revealed that the efficiency of mathematics learning activities has to process and result from efficiencies of 76.77/77.45 to higher than the threshold of 70/70, the computational thinking skills, and the achievement of the students to higher than the threshold of 70% were significant at the .05 significant level.*

Keywords: Efficiency to Mathematics Learning Activities; Computational Thinking Skill; Achievement; Grade 8 Students

Introduction

Mathematics is a subject related to numbers, calculations, and the use of cause and effect to solve problems that plays a very important role in human life and helps in the development of human thought processes to have creative ideas and rational thinking. It also helps to analyze problems and situations in detail, which will lead to accurate and appropriate forecasting, planning, and decision-making to solve the problems. The study of mathematics in the Basic Education Core Curriculum 2008 (Revised 2017) aims to enable all youths to continually learn mathematics according to their potential and provide opportunities for youths to apply the knowledge, skills, and necessary mathematical processes to improve their quality of life, focusing on essential skills for learning in the 21st century and preparing students to be ready to learn things and to pursue a career upon graduation or continue their studies at a higher level (Ministry of Education, 2017).

Computational thinking skills are essential for today's learners. Because students have to face problems in the real world, they need to consider the problems, be able to manage the information related to the problems, test the problem-solving plan to check for errors, and adjust the plan for better (McKenna, 2017) . Nowadays, most mathematical problems are complex in terms of analyzing problems, calculating, or finding solutions. Computational thinking is a problem-solving skill that applies the principles of computer science, consisting of abstraction, decomposition, pattern recognition, and algorithm to systematically solve complex mathematical problems.

After studying teaching and learning approaches that encourage students to develop their computational thinking skills, the researchers realized that the learning management model using the inquiry process with Creative Problem-solving (CPS) can be used to develop computational thinking skills, creative thinking, analytical thinking, and problem-solving systematically for students. It is because inquiry-based learning management is a learning method that encourages students to learn by themselves and try to find solutions on their own, and CPS allows students to practice thinking of new solutions that can be used to solve problems systematically. Inquiry-based learning management focuses on student-centered learning. It allows students to practice and have the freedom to think and express their ideas that can be used to solve problems and create new knowledge. It also allows students

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to fully practice their math skills. It is a 6-step activity process, including a review of previous knowledge, teaching new content, summary, skill training, knowledge application, and evaluation (Institute for the Promotion of Teaching Science and Technology, 2003). However, it is not enough for the development of computational thinking skills because it lacks development in understanding problems in terms of thinking of creative solutions to problems and solving problems in a systematic way. Therefore, the researchers studied the techniques or processes which can be applied to inquiry-based learning management on mathematics that can develop computational thinking skills in all components.

Creative Problem-solving is a model to help you solve problems and manage change creatively. It gives you a set of easy-to-use tools to help translate your goals (Donald, Scott, & K. Brian,2010) and a process that allows people to apply both creative and rational thinking to find solutions to everyday problems. (Dandy, 1986 ; Isaksen, D. & Treffinger, 1994)

The researchers applied CPS in organizing inquiry-based learning activities to develop computational thinking skills. It is a thought process in solving complex problems derived from new ideas, consisting of convergent thinking based on previous knowledge and experience and divergent thinking from creative thinking, which appropriately promote each other for application in creative problem-solving. Treffinger, Isaksen, and Dorval (2003) presented CPS which can be divided into 4 steps: understanding the challenge, generating ideas, preparing for action, and planning your approach. The researchers thought that each step of CPS can improve computational thinking skills in terms of understanding the problem, thinking of creative solutions to the problem, and systematically solving the problem.

According to the aforementioned reasons, the researchers were interested in applying mathematics learning activities on statistics of Matthayomsuksa 2 using the inquiry process with CPS in solving more complex problems to promote students' computational thinking skills so that they can develop their potential in solving mathematical problems and effectively apply the gained skills and knowledge to their daily life.

Research Objectives

1. To develop the mathematical learning activities on statistics by using the inquiry process with CPS to efficiently promote computational thinking skills of Matthayomsuksa 2 students according to the 70/70 criterion
2. To compare the computational thinking skills on statistics by using the inquiry process with CPS of Matthayomsuksa 2 students with the 70 percent criterion
3. To compare the learning achievement on statistics by using the inquiry process with CPS of Matthayomsuksa 2 students with the 70 percent criterion

Research Hypothesis

1. The computational thinking skills of the students learning through the mathematics learning activities by using the inquiry process with CPS are higher than the 70 percent criterion of the full score.
2. The learning achievement of the students learning through the mathematics learning activities by using the inquiry process with CPS is higher than the 70 percent criterion of the full score.

Methodology

1. **Population and Sample**

1.1 The population consisted of 163 Matthayomsuksa 2 students from 5 classes of the Sciences and Mathematics Program studying at Mahasarakham University Demonstration School (Secondary).

1.2 The samples were 41 Mathayomsuksa 2/3 students studying Sciences and Mathematics Program at Mahasarakham University Demonstration School (Secondary) obtained by a cluster random sampling method.

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2. Data Collection Instruments

2.1 The instruments used in the experiment were 7 lesson plans based on the inquiry process with CPS, a total of 7 hours. The mean scores of the appropriateness assessed by the experts were between 4.61-4.78, indicating that the lesson plans are the most appropriate.

2.2 The instruments used for data collection were as follows.

2.2.1 A computational thinking skills assessment, consisting of 3 situations: In each situation, the students' computational thinking skills were assessed in all four components: decomposition, abstraction, pattern recognition, and algorithms. The Item-Objective Congruence Index was 0.67-1.00. The difficulty was 0.54-0.68. The discrimination was 0.59-0.78. The reliability was 0.94.

2.2.2 A learning achievement test of Mathematics 4 on statistics: It was a 20-question, multiple-choice test with 4 choices for each question. The Item-Objective Congruence Index was 0.67-1.00. The difficulty was 0.45-0.75. The discrimination was 0.59-0.98. The reliability was 0.84.

3. Research Design

This research aimed to develop the mathematics learning activities by using the inquiry process with CPS with computational thinking skills of Mathayomsuksa 2 students on statistics. Pre-experimental research using one group posttest only design was employed (Worakham, 2016).

4. Data Analysis

The data analysis in this research was conducted by using the completely revised research instruments with the samples who were Mathayomsuksa 2/3 students at Mahasarakham University Demonstration School (Secondary) studying Mathematics 4 in the second semester of the academic year 2021. The data analysis process was as follows.

4.1. The efficiency of the mathematics learning activities using the inquiry process with CPS of Mathayomsuksa 2 students was analyzed to meet the 70/70 criterion by using the formula for efficiency calculation based on the concept of Brahmawong (2013). The efficiency of the process was calculated from the percentage of the scores from class assignments, including worksheets and tests at the end of each lesson plan. The efficiency of the outcome was calculated from the percentage of the scores from the computational thinking skills test and the learning achievement test of Mathematics 4 on statistics.

4.2. The computational thinking skills were analyzed from the results of Mathayomsuksa 2 students' computational thinking skills test on statistics using the one-sample t-test, compared with the specified criterion (70 percent).

4.3. The learning achievement was analyzed from the learning achievement test of Mathematics 4 on statistics of Mathayomsuksa 2 students using one sample t-test, compared with the specified criterion (70 percent).

Results

This research aimed to develop the mathematics learning activities by using the inquiry process with CPS with computational thinking skills of Mathayomsuksa 2 students on statistics. The research results can be summarized as follows.

1. The efficiency of the mathematics learning activities by using the inquiry process with CPS to promote computational thinking skills in Matthayomsuksa 2 students on statistics was 76.77/77.45, which was higher than the set criterion of 70/70. Results as in table 1

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Table 1 The efficiency of the mathematics learning activities

Scores	**Full score**	$\bar{X}$	**S.D.**	**Percentage**
1. Activity sheet scores and mini-tests at the end of the plan.	126	96.73	6.89	76.77
2. Scores for taking the Computational Thinking Skills Test and post-test	65	49.83	2.58	77.45
The efficiency of the mathematics learning activities (E1/ E2) was 76.77/77.45				

2. The computational thinking skills of Matthayomsuksa 2 students who studied through the mathematics learning activities by using the inquiry process with CPS were higher than the 70 percent criterion with statistical significance at the level of 0.05. Results as in table 2

Table 2 The computational thinking skills.

Test	N	$\bar{X}$	S.D.	t	p
Computational thinking skills	41	33.93	1.85	8.403*	.000

* significance at the level of .05

3. The learning achievement of Matthayomsuksa 2 students who studied through the mathematics learning activities by using the inquiry process with CPS was higher than the 70 percent criterion with statistical significance at the level of .05. Results as in table 3

Table 3 Learning achievement.

Test	N	$\bar{X}$	S.D.	t	p
Learning achievement	41	15.90	1.04	11.667*	.000

* significance at the level of .05

Discussion

1. The efficiency of the mathematics learning activities by using the inquiry process with CPS to promote computational thinking skills in Matthayomsuksa 2 students on statistics was 76.77/77.45, which was higher than the set criterion of 70/70. It is because the teaching and learning management developed by the researchers focused on encouraging the students to solve problems on their own. The students discussed and exchanged their ideas within the group. The teacher presented the problems to each group. Then the students applied CPS to solve the problems. Once the students learned to understand the problems, the teacher asked each group to generate ideas on how to solve the problems. There was not a definite answer to the problems, but a wider choice of solutions. However, what must be considered is choosing the most suitable solution for that period (Cinnamon and Matulef, 1979). The teacher instructed each group to write the clear problem-solving steps in a well-structured and effective way (Ministry of Education, 1998). After that, the problem-solving steps were used to solve the problems. After the problems were solved, the teacher used question-and-answer conversations about the solutions with the students until the students in each group concluded. After the students solved the problems in the form of group activities, the teachers presented new problems different from the situations in the group activities to each student. The students were encouraged to practice solving problems on their own by using CPS created from the group activities. The process began with understanding the problems, generating solutions, choosing the most suitable solution and writing clear problem-solving steps, and using them to solve the problems. Once the students practiced solving

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problems until they became proficient, the teacher presented more complex or everyday situations to the students. The students solved the problems using the phenomena they were facing or experiencing and were ready to challenge their thinking (Suksri-ngam, 2003). As a result, the students can apply the knowledge gained to solve more complex problems. The students applied the CPS process to solve the problems. This activity is a teaching method that focuses on the process of seeking knowledge that helps students to discover truths by themselves and have direct experience in learning (Laohapaiboon, 1999). It is consistent with a study by Indiana Creative Problem-Solving Initiative Blumberg Center (2003) on problem-solving abilities. The students learned about CPS. It was found that there was an increase in the problem-solving ability of those who learned about CPS. In addition, Tananta (2019) conducted a study titled "A development of mathematics learning activities by using inquiry process with Polya's problem-solving to promote mathematics problem-solving ability in Matthayomsuksa 5 students. The study results revealed that the students who learned by using the inquiry process with Polya's problem-solving on vector had mathematical learning achievement higher than the 70 percent criterion at a 0.05 level of significance.

2. The computational thinking skills of Matthayomsuksa 2 students who studied through the mathematics learning activities by using the inquiry process with CPS were higher than the 70 percent criterion with statistical significance at the level of .05. It is because the learning process focused on the development of problem-solving abilities by training the students to search for knowledge. The teacher asked questions to encourage the students to use the thought process until they discovered feelings or correct solutions by themselves, and summarized them as principles, rules, or methods for solving problems and applied them to control, improve, change and create things widely. This is an important component of the inquiry process teaching (Moolkum and Moolkum, 2002), and another factor is the creative problem-solving (CPS) process developed by the researchers. CPS is the process of solving problems creatively and making it easy to achieve the set goals (Treffinger, Isaksen, and Dorval, 2003). It mostly occurs in situations where there is no definite solution to the problem. This gives a wider choice of solutions. But what must be considered is choosing the most suitable solution for that period (Cinnamon and Matulef, 1979). This concept is following the learning activities in this research as the problems were given to the students, so they can understand the situations. Then they would isolate the components of the problems, cut out unnecessary parts of the solutions and find or apply the solutions that can be used to solve the problems and select the most suitable way to solve the problems, and clearly write the correct sequence of the solutions and use it to solve the problem correctly. Computational thinking is a way of thinking about defining a problem, and the solution can be presented in a step-by-step manner (Aho, 2012). This corresponds to (Mitchel and Kowalk. 1999; Poompachati, 2009), stating that creative problem-solving (CPS) is a way of thinking and acting. It consists of (Creative) which refers to peculiar and unique ideas that the creator must have at least one for finding the solution; (Problem) which is a situation that expresses a challenge, opportunity, or something that needs attention, and (Solving) which is a way of planning to answer the question, organize a meeting or judge the problem. In addition, the learning activities developed by the researchers together with CPS are consistent with the research of Gonzalez et al. (2016) which found that computational thinking is related to problem-solving and understanding of representations of things, and being able to use reasons to solve problems. A study by Leonard et al. (2016) examined the improvement of computational thinking abilities of 124 junior high school students. It was found that the learning process aiming at students to solve problems through designing and creating a workpiece can promote computational thinking. Sittikhetkron and Sawangmek (2021) conducted a study on the development of computational thinking skills through 5Es inquiry learning activities with the board game and Formula Coding on the population in the pandemic for Grade 12 students. It was found that the learning activities consisted of engagement with pandemic news, exploration of pandemic data to design the prevention and solving by using formula coding with Microsoft Excel program, explanation of population graphs from changed trend, elaboration of population dynamics illustrated by Covidea board game before organizing group discussion for concluding population and pandemic. Moreover, the

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students' CT skills were at the highest level, corresponding to the increase in the development of computational thinking skills while studying, which was also at the highest level. Jenjit (2003) researched geometry teaching activities using creative problem-solving for high school students with mathematical abilities. The results were as follows. 1) More than 75% of the students with mathematical abilities studying through geometry teaching activities using creative problem-solving passed the 75 percent criterion with statistical significance at the level of .01. 2) After studying geometry teaching activities using creative problem-solving, the students had creative problem-solving behaviors, consisting of flexibility, originality, and elaboration at a high level in all aspects.

3. The learning achievement of Matthayomsuksa 2 students who studied through the mathematics learning activities by using the inquiry process with CPS was higher than the 70 percent criterion with statistical significance at the level of .05. It is because the developed activities focused on self-study. The students had to finish worksheets and shared their learning with friends and teachers. Therefore, they can discover knowledge from both learning materials and the practice of finding creative answers with the clear purpose of problem-solving. This is consistent with the concept of Moolkum and Moolkum (2002) who discussed inquiry-based learning management, which is a learning process that focuses on developing problem-solving abilities through training students to know how to search for knowledge. In this study, the students used the thought process until they discovered feelings or correct solutions by themselves, summarized them as principles, rules, or methods for solving problems, and applied them to control, improve, change and create things widely. In addition, in the learning process, worksheets were used, and the students did activities both in groups and individually, allowing them to exchange ideas with friends. They also discussed their different opinions within the class. Moreover, the mathematics learning activities using the inquiry process focused on stimulating the students to learn and search for knowledge using the reasoning process (Boonchuvong, 1995). The activities also focused on the students' thinking processes in solving complex problems using new ideas to be applied in creative problem-solving (Treffinger, Isaksen, and Dorval, 2003) . These activities allowed the students to know what to look for and what information that can be used to help them find answers. The students were also encouraged to apply the gained knowledge to benefit and use in daily life. Thus, their academic achievement was better. This is consistent with a study by Khaoprae and Cheausuwantavee, studying mathematical analytical thinking ability and learning achievement on statistics among ninth-grade students through the inquiry cycle learning management. The study results pointed out that the learning achievement on statistics among ninth-grade students after the inquiry cycle learning management was statistically higher than the 70 percent criterion at a 0.05 level of significance. It also corresponds to a study by Pimmun (2014), investigating the effect of synthesization between inquiry cycle (5Es) and Polya's problem-solving process on the topic of the application of linear equations with one variable. The study revealed that the efficiency of the Inquiry Cycle (5Es) and Polya's problem-solving process learning management was 80.56/ 80.56. In addition, the mathematics achievement of the students that learned by the Inquiry Cycle (5Es) and Polya's problem-solving process was higher than the criterion at the .05 level of significance.

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Recommendations

4. Recommendations

4. 1 General recommendations: The study revealed that the efficiency of mathematics learning activities have to process and result in efficiencies of 76.77/77.45 to higher than the threshold of 70/70, the computational thinking skills, and the achievement of the students to higher than the threshold of 70% was significant at the .05 significant level. the general recommendations for the application of research findings are as follows.

4.1.1 Since students are not familiar with the mathematics learning activities by using the inquiry process with CPS, teachers should study the steps of the learning activities and explain the steps in solving problems clearly. Also, the problems in the worksheets should not be too complicated.

4.1.2 During the activities, teachers must carefully observe the behavior of the students and advise those who have doubts.

4.1.3 Because the mathematics learning activities by using the inquiry process with CPS focus on encouraging students to build their own knowledge, teachers should serve as facilitators or mentors, giving advice and asking students to stimulate them to think rather than directly telling them the answers. As a result, students are encouraged to adjust their thinking and better understand the content.

4.1.4 The mathematics learning activities by using the inquiry process with CPS focus on enabling students to solve problems in a step-by-step manner, so teaching and learning take quite a lot of time. Therefore, teachers should plan and manage time properly.

4.1.5 The worksheets for group activities should be concise and not contain too much content because it may cause students to be confused and fail to understand the activities, causing boredom, and it may take too much time to complete the worksheets.

4. 2 Recommendations for further research: The recommendations for further research findings are as follows.

4.2.1 Learning management activities that promote and develop the ability to write problem-solving steps should be studied.

4.2.2 Online materials that can be used with other learning activities that promote and develop computational thinking skills should be researched.

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