IIAI Open Conference Publication Series
IIAI Letters on Institutional Research
Vol. 003, LIR097
DOI: https://doi.org/10.52731/lir.v003.097

The Synthesis of Learning Management Models that Promote Mathematical Problem Solving for Primary School Students in Thailand

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Abstract

Problem solving is the main purpose of mathematics learning and the key procedural skill of mathematics instruction. The purpose of this study is to synthesize and evaluate a learning management model that promotes mathematical problem solving for primary school students in Thailand. This research was divided into two phases: 1) the synthesis of learning management model in which a qualitative research method by document analysis and focus group discussion were considered. The research tool is the documented form of data analysis whose data were obtained from the study of a learning management model promoting mathematical problem solving, and 2) inspecting the validity of the learning management model by using a quantitative research model in which the research method was a survey. The research tools consist of a questionnaire to assess the appropriateness of the learning management model that promotes mathematical problem solving for elementary school students in Thailand. In addition, the data were analyzed by analytical lectures and interpretive summaries. The statistics used in the research were mean and standard deviation. The research results showed that 1) the mathematical problem-solving process included five steps as follows: 1. analyze and understand the problem, 2. plan to solve the problem, 3. choose a strategy for problem solving, 4. Use the strategy for problem solving, and 5. Evaluate the answer and method; and 2) the result of the validity of the learning management model that promotes mathematical problem solving for elementary school students in Thailand from nine experts. It was found that the overall appropriateness was at the highest level (M=4.73, S.D.=0.48) and it could be utilized in learning management that enhanced mathematical problem solving efficiently.

Keywords: mathematics, mathematical problem-solving , process model

1 Introduction

In the context of Thailand's development, education is an important mechanism for developing human resources to possess quality, potential, skills, knowledge, abilities and competencies to be ready for the changing of global conditions. The educational situation in Thailand recently still has limitations in many dimensions, namely education quality which reflects that national and international overall results are still at a dissatisfying level [1] The clear evidence is shown by the results of the National Testing Service (O-NET), which is assessed annually by the National Testing Institute. The results showed that students at all levels scored less than 50 percent, especially mathematics with the lowest score. [2] It is consistent with the results of mathematics

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learning assessment of learners from the National Test (NT), which indicates the average score of basic abilities in numeracy and reasoning ability, which are two of the basic abilities related to learning mathematics of students in Grade 3 nationwide is below 50 percent, the minimum standard. In particular, the average computational proficiency score was the lowest. [3] The International Assessment Program for International Student Assessment (PISA) defines PISA 2022 mathematical intelligence as an individual's ability to reason mathematically and can convert the problem by using mathematics and interpret mathematical results for problem-solving in a real-world context. [4]. Although problem-solving ability is a necessary skill in learning mathematics, [5] unfortunately, the score in the last PISA assessment in 2018 of Thai students is as follows: reading score at 393, science score at 426 and mathematics score at 419, all below the OECD average in all three areas. [6] It corresponds to the study of international trends in mathematics and science education in 2015 [7] which is a project undertaken by the International Association for Evaluation of Educational Achievement in which a four-year continuous assessment has been conducted. It was reported that most students in Thailand had low mathematics learning ability. This reflects that the students still lack the ability to solve mathematical problems, which is consistent with most teaching and learning management that still focuses on content, resulting in students lacking effective prob-lem-solving skills. In addition, Thailand's educational reforms are not consistent with the world's direction. [8]

For the curriculum of Mathematics Department (revised edition of 2017) according to the core curriculum of basic education B.E 2551, it focuses on students to use mathematics to solve problems in everyday life and to understand and solve mathematical problems [3]. The process of solving mathematical problems is the ability to understand problems, think analytically, plan solutions and select appropriate methods based on the reasonableness of the answer along with the accuracy [9].

Although the structure of the solution is still unclear, it is normally claimed that solving mathematical problems requires the interpretation and the analysis of the problem, both of which may be a single step or multiple steps and can identify the essential requirement for mathematical operations. Some problems may contain relevant information and irrelevant information. [10] concluded that the problem-solving process consisted of three steps as follows: 1. reading and understanding problem, 2. organizing strategy and solving problem), and 3. confirming the answer and the process. It is consistent with Ramida [11] claiming that the ability to solve mathematical problems included three steps: 1. understanding the problem, 2. solving the problem, and 3. summarizing the answer. However, [12] proposed four steps to solve the problem as follows: 1. the understanding of the problem, 2. the selection of the strategy, 3. the application of the strategy, and 4. the evaluation of the solution. It is consistent with [13], a mathematical problem-solving process was suggested as follows: 1. understanding the problem, 2. compiling a list of problem-solving solutions, 3. making a plan on how to solve the problem, and 4. reviewing the solutions that have been implemented. Also, it corresponds with [14] stating that the mathematics problem solving process had the following steps: 1. students had to understand the problem of the problem given, 2. students were able to interpret the problem, 3. students were able to find solutions to solve the problem appropriately, and 4. after receiving the answer, the student must check the answer to see if the answer is correct or not.

Following the research study, it was found that the obstacles in problem solving of Thai students started from step 1 where the students were unable to interpret the problem. As a result, they do not understand what the question asks or what the question wants them to find. Therefore,

they are unable to proceed to step 2, which is an integration of knowledge, concepts, skills, and mathematical processes to select operational strategies. [15] and could not identify the strategy that would lead to the selected action from step 2 to step 3 and ultimately the students could not actually solve the problem in step 4. These prevent students from completing step 1 to step 4. Finally, they were unsuccessful in solving the problem, in which step 1 and step 2 were an important period since they were in the initial stage and consisted of problem interpretation [16]. It is consistent with the action plan where it is very important to consider selecting a solution that is suitable for that problem, which can be regarded as another step [3]. If there are obstacles in this phase, students will not be able to proceed to other phases. Therefore, attention should be paid to developing learning processes that foster student understanding in interpreting from problem-solving to strategic choice. Then they are requested to proceed to write sentences, symbols or other mathematical language to lead to complete problem solving.

As a result, it is very necessary to synthesize and to find the validity of the learning management model that promotes mathematical problem solving for primary school students in Thailand. The results obtained will be beneficial to mathematics teaching and mathematics teachers who will apply the learning management model that promotes mathematical problem solving to apply in mathematics teaching, especially in the context of Thailand, to be more effective.

2 Literature Review

The learning management model that promotes problem solving in mathematics

Mathematical problem solving is the process of thinking to solve problems in mathematical situations where the answer cannot be found immediately [17]. The meaning of the mathematical situation must be interpreted [18]. It requires prior experience, knowledge, memory, understanding and analysis [19]. The process is a step-by-step procedure to find a relationship and has action plan [20]. Students should learn, practice and improve themselves. Solving mathematics problems provides students with a wide range of ways to think [3]. Mathematics plays an important role in various aspects of life as well as being a basic skill that students can use in everyday life throughout their lives, such as counting, measuring, etc. [21]. The mathematical problem-solving process consists of 1. understanding the problem, 2. planning to solve the problem, 3. solving the problem, and 4. summarizing the answer [12], [13], [14], [22], [23], [24]. [25] discussed the process of solving mathematical problems as follows: 1. the finding of the problem relationship, 2. drawing a mathematical diagram, 3. the problem solving, and 4. the traceability), and [10] summarized the problem-solving process consisting of three steps as follows: 1. reading and understanding the problem, 2. organizing strategy and solving the problem, and 3. confirming the answer and process. In addition, scholars mentioned to some different mathematical problem-solving processes. [26] claimed that there were five steps in solving the problem as follows: 1. read and understand the problem (read), 2. analyses and syn-thesize information from the problem (explore), 3. choose a strategy to solve the problem (select a strategy), 4. solve the problem (solve) 5. look back or expand (look back and extend). As a result, solving problems is the destination and learning process in mathematics. Students have to put the problem into the problem-solving process

by applying mathematical knowledge, steps, processes, strategies/solutions [27]. The strategies that students have to choose to solve problems include drawing a picture, finding patterns, working backwards, guessing and checking, simplifying the problem, making a list, eliminating and changing the perspective [3].

3 Research Methodology

The synthesis of a learning management model that promotes mathematical problem solving for elementary school students in Thailand was divided into 2 phases:

Phase 1: The document of a learning management model that promotes mathematical problem solving was synthesized by a qualitative research model from document analysis and focus group discussion. The research tools include the document record of data collection, including: 1) analyzing the document of research related to a learning management model that promotes problem solving in mathematics and the study of the basics of the teaching and learning context in Thailand. 2) synthesizing a draft learning management model based on the results of the component analysis of the learning management model in Step 1) drawn up as a learning management model that promotes mathematical problem solving and assigning experts for group discussions in order to brainstorm ideas about the synthetic teaching style. There is the total of nine experts who are involved in learning management that promotes mathematical problem solving, including seven professors who have an academic rank of assistant professor or higher and are a graduate of a Ph.D. and have at least five years of research experience, and two instructors of mathematics in elementary schools, academic standing teachers, professional teachers and specialist teachers.

Phase 2: The validity of the learning management model that promotes mathematical problem solving was checked by using a quantitative research model and survey research. Research tools consisted of a questionnaire to assess the suitability of a learning management model that promotes mathematical problem solving for primary school students in Thailand. For the data collection, the researcher used a learning management model that promotes problem solving in mathematics and proposed learning management design to the experts to examine the validity of learning management models that promote mathematical problem solving in order to improve and edit according to the suggestion The tool used was a questionnaire created by the researcher, verified its content validity by five experts. The questionnaire received IOC between 0.67-1.00 and the reliability at 0.95. and the data analysis using basic statistics, including mean and standard deviation.

4 Research Results

1. The results of the synthesis of a learning management model that promotes mathematical problem solving for elementary school students in Thailand.

Table 1: Results of the synthesis of steps in learning management that promote mathematical problem solving.

The Ministry of Education [3]	Tarzimah Tambychik [10]	Ramida Chanfoun [11]	Ersoy [12]	Siti Qomariyah [13]	Thadapanitsa-dee Sukonwi riyakul [14]	Panyapon Thongdee [22]	Siska Apulina Peranginangin [23]	Phuong Uyen [24]	Ninnuan [25]	Krulick & Rudnick [26]	**The Researcher**
1. Understand the problem or analyze the problem	1. Reading and understanding problem	1. Understand the problem - Specify what the problem is given to. - What does the challenge require?	1.Understand-ing of the Problem	1. Understand the problem	1. Students must under-stand the prob-lem of the problem - What does the problem give? - What do you want to ask? 2. Students can interpret the meaning of the problem	1. Understand the problem	1. Understand the problem	1. Identify the problem - Analyze the situation	1. The finding of the problem relationship - Analyze the problem and understand the problem	1. Read - Understand the problem - Analyze what the question requires - What infor-mation does the question provide?	1. Analyze and understand the problem - What's the problem? - What do you want to find? - What is as-signed? - What are the conditions?
2. Make a plan to solve the problem. - Solve the problem in any way - How are things related to the prob-lem? to formu-late a solution The method contains - Draw a Pic-ture - Find a Pat-tern	2. Organizing strategy and solving prob-lem			3. Make a plan on how to solve the prob-lem		2. Problem solving plan-ning	2. Plan		2. The writing of mathemati-cal diagrams - Draw a solu-tion plan	2. Explore - Use the in-formation to plan the action to solve the problem.	2. Make a plan to solve prob-lems - How to solve the problem - What is the information in the question related to?
			2. Selection of the Strategy	2. Compile a list of prob-lem-solving solutions	3. Students can find solutions to use in solv-ing problems appropriately			2. Propose a solution - Choose the right method to solve the problem			3. Choose a strategy for problem solv-ing - Draw a Pic-ture - Find a Pat-tern - Work

The Ministry of Education [3]	Tarzimah Tambychik [10]	Ramida Chanfoun [11]	Ersoy [12]	Siti Qomariyah [13]	Thadapanitsadee Sukonwiriyakul [14]	Panyapon Thongdee [22]	Siska Apulina Peranginangin [23]	Phuong Uyen [24]	Nimuan [25]	Krulick & Rudnick [26]	**The Researcher**
- Work Backwards - Guess and Check - Simplify the problem - Make a list - Eliminate - Change of perspective											Backwards - Guess and Check - Simplify the problem - Make a list - Eliminate - Change perspective
3. Solve problems - Execute according to the plan		2. Problem solving - carry out problem solving	3. Application of the Strategy			3. The action to find answers	3. Carry out the plan	3. Implement and present the solution	3. The problem solving	4. Solve - Act according to the method that has been planned to get the correct answer.	4. Take action to solve the problem - Act according to the chosen plan or method
4. Check - The reasonableness of answers	3. confirming the answer and process	3. Summarize the answer	4. Evaluation of the Solution	.4Review the solutions that have been implemented	4. Check the answer to see if the given answer is correct or not	4. The summary of answers	4. confirm answer	4. Research in depth the solution - Explore the possibilities of the results	4. The traceability - Check the correctness of the answers. - Check the accuracy of a strategy or mathematical procedure	5. Look back and extend - check answers - Link between facts and questions	5. Evaluation of the answer and method - Validate the process - Check the reasonableness of answers

Based on the information in Table 1, the study of processes and procedures for solving mathematical problems from related literature above, the researcher has synthesized a mathematical problem-solving process model and recommendations of experts from focus group discussions. There are a total of five steps with the details as follows:

1. The analysis and the understanding of the problem is the step where students have to analyze the various parts of the problem. Students must understand the problem to determine: what is the problem? What do they want to know? What is the problem assigned? and what are the conditions?

2. Planning to solve the problem focuses on the problem-solving method in which students must consider which information in the problem relates to which subject in order to plan how to solve the problem.

3. Choosing a strategy for problem solving requires student to select the appropriate solution to the problem in order to carry out the plan. These include drawing a picture, finding a pattern, working backwards, guessing and checking, and simplifying the problem, making a list, eliminating and changing perspectives. Students can select one solution or a combination of methods to get the correct answer.

4. The use of the strategy for problem solving is the step where students implement their chosen plan and solution. If the selected plan or method does not provide an answer, students must recheck the planning process or select a new method until an answer is obtained.

5. The evaluation of the answer and the method requests students to verify the validity of the process, the reasonableness of the answer to ensure that the answers obtained are correct.

Figure 1: Learning management model that promotes problem solving in mathematics

2. The results of verifying the validity of the learning management model that promotes mathematical problem solving for primary school students in Thailand

Table 2: Shows the validity of the learning management model that promotes mathematical problem solving for elementary school students in Thailand.

Learning Management that Promotes Problem Solving in Mathematics	Mean	Standard Deviation	Opinion Level
1. Analyze and understand the problem	4.67	0.50	Highest
- What's the problem?	4.56	0.53	Highest
- What do you want to find?	4.67	0.50	Highest
- What is assigned?	4.89	0.33	Highest
- What are the conditions?	4.67	0.71	Highest
2. Plan to solve problem	4.89	0.33	Highest
- What is the information in the question related to?	4.89	0.33	Highest
- How to solve the problem?	4.56	0.53	Highest
3. Choose a strategy for problem solving	4.56	0.73	Highest
- Draw a picture	4.56	0.73	Highest
- Find a pattern	4.89	0.33	Highest
- Work backwards	4.56	0.53	Highest
- Guess and check	4.56	0.53	Highest
- Simplify the problem	4.56	0.53	Highest
- Make a list	4.89	0.33	Highest
- Eliminate	4.67	0.71	Highest
- Change perspective	4.56	0.53	Highest
4. Use the strategy for problem solving	4.79	0.44	Highest
- Act according to the chosen plan or method	4.67	0.71	Highest
5. Evaluate the answer and the method	4.79	0.44	Highest
- Validate the process	4.89	0.33	Highest
- Check the validity of the answers	4.56	0.53	Highest
The overall of the suitability assessment	4.73	0.48	Highest

Table 2 shows the results of checking the validity of the learning management model that promotes mathematical problem solving for primary school students in Thailand in five steps. It was found that the result of checking the validity of the learning management model that promotes mathematical problem solving for elementary school students in Thailand from nine experts has the overall appropriateness at the highest level with an av-erage of 4.73 and the standard deviation at 0.48. When considering every step, it was found that all steps were appropriate at the highest level.

5 Conclusion and Discussion

The results of the synthesis of mathematical problem-solving processes consist of five steps as follows: 1. analyze and understand the problem, 2. plan to solve the problem, 3. choose a strategy for problem solving, 4. Use strategy for problem solving, and 5. evaluate the answer and the method. Then, the results of the synthesis of learning management models that promote mathematical problem solving were considered by experts to assess the validity of the learning management model that promotes mathematical problem solving for primary school students in

Thailand. The result showed that it was appropriate at the highest level which might results from that the researcher synthesized the documents and summarized the recommendations from the group discussions and then found the validity of the learning management model. It was found that in step 1, the analysis and understanding of the problem requires students to analyze the various parts of the problem. Students must understand the problem to determine: What is the problem?; What do they want to know?; What is the problem assigned?; and what are the conditions. It is consistent with [28] that to understand the problem, students have to understand the mathematical problem clearly, exchange knowledge with each other and specify the purpose of the problem. From the research of [29], students can analyze problems well by using questions that encourage them to analyze problems, which is consistent with [30], [31]. To understand mathematical problems should be initially started by students themselves, so they can realize the problem by themselves. The teacher should motivate the learners by using questions, giving suggestions and creating an atmosphere of expressing each student's opinions [32], in which the students were able to use their problem-solving skills well as most of the students can understand the problem. In step 2: planning to solve the problem requests students to consider which information in the problem relates to which subject in order to plan how to solve the problem. The research of [33], [34] claimed that in planning to solve problems, students must consider the problem and be able to write a description of how to find the answer to the problem or find ways to solve the problem correctly and appropriately. In step 3: choosing a strategy for problem solving encourages students to select a solution that is appropriate for the problem in order to carry out the plan. These include drawing a picture, finding a pattern, working backwards, guessing and checking, simplifying the problem, making a list, eliminating and changing perspectives. Students can select one solution or a combination of methods to get the correct answer. It is consistent with the research by [35], claiming that most of Singapore's Grade 4, 5 and 6 students were able to choose appropriate problem-solving strategies to solve these problems and select appropriate problem-solving methods to clearly communicate their problem-solving process [36]. Choosing the right strategy to solve problems is a technique that helps develop ideas and equip them with the ability to think differently in a limited time. In step 4: the use of the strategy for the problem solving supports students to implement their chosen plan and solution. If the selected plan or method cannot find an answer, they must recheck the planning process or choose a new method until the answer is obtained. It is consistent with [37] that students proceed according to their chosen method found in the self-learning stage. Finally, in step 5: the evaluation of the answer and method urges students to validate the process and check the reasonableness of the answer to ensure that the answers obtained are correct. It was consistent with [38], [39] claiming that students are required to interpret the results from the action into the results of the situation and recheck the answers. It is a step that encourages students to check their answers.

Acknowledgement

This work was supported by Innovation and Cognitive Technology Research Center, Faculty of Education, Khon Kaen University.

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