



ENHANCING PROBLEM-SOLVING SKILLS OF 8th-GRADE STUDENTS IN LEARNING THE FIRST-DEGREE EQUATIONS IN ONE UNKNOWN

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ABSTRACT

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Mathematics education aims to help students understand and solve problems in their daily lives. Facilitating mathematical problem-solving for most students is a major challenge for teachers and students. The research was carried out to support students in developing their ability to resolve problems by learning the first-degree equations in one unknown. This experimental study was conducted on a random sample of 82 eighth-grade students at An Thoi junior high school in Can Tho City, Vietnam. This sample of 82 students was divided equally in experimental group and control group with 41 participants each. The tools used were real-world problems associated with the first-degree equations in one unknown. During the experiment, data were collected through study sheets, pre-test and post-test, and student interviews. Quantitative and qualitative analysis methods were applied to evaluate the results obtained and verify research hypotheses. Research results showed that most experimental group students showed improvement in the manifestation of problem-solving ability. Furthermore, it was observed that the problem-solving activities positively impacted students' positivity, initiative, creativity, and confidence in learning. It is recommended to provide more opportunities to students for practicing problems of the first-degree equations in one unknown, showing them how to discover, pose and solve problems encountered in learning in the lives of individuals, families and communities.

Contribution/Originality: The paper's primary contribution is finding that the teaching process impacted students, helping them develop real-world problem-solving abilities. Additionally, because the experimental results were analyzed and evaluated in three areas, such as knowledge, skills, and attitudes, the findings had greater validity.

1. INTRODUCTION

It is evident that developing students' problem-solving abilities is one of the significant challenges facing the teachers and academicians all over the world (Greiff, Holt, & Funke, 2013). Problem-solving in math helps students cope with life problems by applying mathematical knowledge and skills (Osman et al., 2018). The lack of problem-solving capacity limits the usefulness and power of mathematical ideas, knowledge, and skills (Farida, Bagus, & Maya, 2018; Uyen, Tong, Loc, & Thanh, 2021). Moreover, focusing on problem-solving aspects in lessons contributes to the development of students' higher-order thinking. Therefore, it can be said that problem-solving plays a critical role in math education, and most of the student learning is the outcome of problem-solving lessons (Ersoy, 2016). Studies provide diverse definitions of problem-solving, highlighting its multidimensional traits. In

general, problem-solving is defined as a cognitive process towards achieving a particular purpose when the subject does not have a solution (Greiff et al., 2013; Lai, Zhu, Chen, & Li, 2015). In terms of mathematics, Cockcroft (1982) thinks that problem-solving capacity is the ability to apply mathematics in solving a variety of different situations (cited by Kaur (1997)). The National Council of Supervisors of Mathematics (NCSM) regards problem-solving as a process of applying knowledge from previous problems to new, unfamiliar situations that involve asking questions, evaluating situations, converting results, plotting graphs, and using trial and error (NCSM, 1989; cited from Farida et al. (2018)). When it comes to the concept of perception, according to Nafees (2011), solving the problem is a rather complicated process that requires an immense amount of thought and effort, requiring the use of such high-level cognitive tools as visualization, relationship, abstraction, understanding, application, reasoning, and division analysis (cited from Behlol, Akbar, and Sehrish (2018)).

Various problem-solving models have been extensively studied in the past, of which Polya's model is the most popular one. Studies by Syahrole, Saman, Kin, and Chin (2016); Guzman (2018); Ersoy (2016); Farida et al. (2018); Liljedahl, Santos-Trigo, Malaspina, and Bruder (2016) have viewed the Polya model as very effective in problem-solving. Precisely, the Polya model consists of four phases: problem exploration, planning, implementation of a plan and research (Polya, 1988) or problem exploration, strategy determination, execution of the strategy was selected and evaluated (Polya, 1945; cited in Ersoy (2016)). Students express what they understand about the problem at the problem understanding stage, and identify various types of information they have or do not have which indicates their current state. As they progress through the strategic planning process, students decide which processes are required, including calculating, drawing, and writing, to solve the problem's requirements. Next, they proceed to apply the strategy, and then must go through the strategy step-by-step to ensure it will work. To qualify at the evaluation stage, students must be in charge of ensuring the plans are correct. They will have to define everything they have already accomplished and where they have been (Miller, 2000; cited from Ersoy (2016)).

Based on Osman et al. (2018), students will have better reasoning in various aspects of their lives if they utilize problem-solving. Through problem-solving, students use the skills of analyzing, summarizing options, identifying causes, evaluating strategies or options to face and resolve contradictions, and ultimately implementing the most effective plan (Osman et al., 2018). Additional problem-solving strategies support students' acquisition of more deeply understood critical thinking, reasoning, and comprehension (Schoenfeld, 1992). Furthermore, many studies have shown that organizing activities that force students to solve problems and reasoning is an effective method to promote other competencies to understand concepts and processes (Collins, 2012; Granberg, 2016; Warshauer, 2015) cited in Sidenvall (2019). More specifically, problem-solving contributes to improving students' enthusiasm in problem analysis, assertiveness, and confidence in problem-solving; to make students more aware of the problem-solving strategy, the meaning of the problem-approaching sequence. They also recognize that problems can be dealt with in multiple ways and that increasing students' abilities to solve problems utilizing multiple approaches will better prepare them for success (Hoon, Kee, & Singh, 2013).

Large number of recent studies have found that the problems that are entirely unfamiliar to students do assist in their problem-solving abilities (Angateeah, 2017; Jäder, Lithner, & Sidenvall, 2020; Ozreçberoğlu & Çağanağa, 2018; Saleme & Etchells, 2016; Saygılı, 2017). According to London (1993), to develop students' problem-solving abilities, unfamiliar problems need to have the following characteristics: First, the problems require students' awareness of the understanding and recognizing the problem for themselves, problem-solving methods, and perseverance in problem-solving. Second, there should be numerous possible solutions to open problems. Third, students should be allowed to approach the problem in many different ways, to consider various alternatives, and to focus on their strengths when searching for a solution. Fourth, problems like these necessitate an understanding of higher-order thinking. Fifth, the students should be able to utilize what they have learned to deal with these problems (cited by Saygılı (2017)). Besides, many studies show that applying Realistic Mathematics Education (RME) and problem-based teaching (PBL) in teaching has tremendous implications for the development of the

problem-solving capacity of students (Farida et al., 2018; Karyotaki & Drigas, 2016; Simamora, Sidabutar, & Surya, 2017). In particular, Yasin et al. (2020) have shown the effectiveness of applying the Search-Solve-Create-Share (SSCS) model to develop students' problem-solving capabilities. This model corresponds to four problem-solving steps: finding out the problem (searching), planning to solve the problem, building a strategy to solve the problem (creating), and communicating the obtained plan. (share) (Yasin et al., 2020). Ozreçberoğlu and Çağanağa (2018) have summarized specifically that teachers should concentrate on when to instruct students in order to increase their problem-solving abilities within the teaching methodology framework. Accordingly, teachers need to design the best way to start and end the lesson, which methods to apply, what tools and means to choose, and how long activities should take place (Gürkan et al. , 2004; cited in Ozreçberoğlu and Çağanağa (2018)). Teachers also need to develop such thinking methods that should help students develop problem-solving rules and strategies, and which are reflected in formulas when teaching problem solving (Soylu & Soylu, 2006; cited from Ozreçberoğlu and Çağanağa (2018)). As a result, students can learn to integrate conceptual knowledge and process knowledge with new strategies to form new types of problems (Olkun & Toluk, 2004; cited in Ozreçberoğlu and Çağanağa (2018)). The general principle is that when students solve problems, they should pay attention to alternative wording of suggestions; to understanding the problem as a whole; to selecting the relevant data; to devising an appropriate strategy; and to giving feedback. Finally, testing will ensure that the problem is correctly solved. In case students make mistakes, teachers need to explain, prove, and encourage students that there is not one single method for each question and ask students to check their answers (Karataş & Güven, 2003; cited in Ozreçberoğlu and Çağanağa (2018)). Nevertheless, students are confronted with many difficulties while they are learning to cope with problems. Teachers, too, who want to apply problem-solving techniques, face additional challenges. According to Lester, Garofalo, and Kroll (1989), in problem-solving, students often encounter obstacles in spatial visualization, the ability to grasp the structural characteristics of problems, and factors of attitudes and beliefs, background knowledge and experience such as learning history, familiarity with types of problems (cited in Kaur (1997)). In particular, for verbal problems, Saleme and Etchells (2016) assert that students could not understand the problem because they cannot visualize critical information by diagrams or diagrams, grade level; they do not understand the hypothesis of the problem in order to convert the problem into an equation; and therefore face difficulty in analyzing the problem. Thus, when students fail to convert the information or convert incorrectly, they search for keywords in the problem instead of understanding it. Students frequently find it challenging to determine the correct calculation for equations because they have either neglected to record or calculate their calculations while performing the calculations.

Students are also inevitably distracted if the problem or question gives them unnecessary information, but if the problem or question is well-reasoned, they will have a clear understanding of what they are facing. According to Angateeah (2017) and Yayuk, Purwanto, and Subanji (2020), different types of students often encounter different difficulties in problem-solving. Specifically, students with high results often make mistakes due to lack of care and subjectivity; middle-achieving students often make process mistakes, while low-performing students have difficulty visualizing and presenting problems (Angateeah, 2017). At the same time, teachers themselves face problems when they are attempting to teach problem-solving. Greiff et al. (2013) points out some fundamental difficulties in problem-solving teachings, such as insufficient period time for teachers to focus on designed activities; dense design of the subject's curriculum makes it impossible for teachers to incorporate unfamiliar issues into their lessons. Furthermore, teachers are not generally familiar with problems they are not previously accustomed to, and they are less likely to understand a variety of different types of exercises and classroom activities.

Teaching students to find solutions to various problems is a common goal of the education system of most countries. There have been numerous studies on problem-solving capacities, especially those concerned with capabilities. Kaur's theoretical research on problem-solving problems in mathematics shows that problem solving is a complex process that requires individuals to perform a mathematical task to combine control over general and

specific knowledge (Kaur (1997)). The study also shows how students at different levels of education can successfully solve the mathematical content of problems. It confirms that such students require studying a problem-solving teaching curriculum at different education levels in order to develop problems solving skills.

In the context of problem-solving models, Syahrole et al. (2016) introduced a new model for solving verbal problems, which they viewed as incomprehensible. The research highlights how this model motivates students to figure out solutions to problem they have never encountered before. In this case, the authors posit that this model has significant implications for improving Malaysian education's capacity to promote higher-order thinking skills. To achieve that, the authors proposed an integrated model, a composite product of many different problem-solving models such as Polya, Schoenfeld, and Mason. In light of these, the authors' model can be stated as consisting of four primary steps, including inclusion, analysis, action, and evaluation.

Yayuk et al. (2020) recommend analyzing students' creative thinking ability through problem-solving questions. The study performed qualitative analysis on a total of 110 5th graders in Malang Municipality and Regency. The research results show that high math results demonstrate the right competencies in fluency and flexibility but still have difficulty in originality. On the whole, students show impressive flexibility, but they remain stagnant when it comes to fluency and originality. Students in this group understand the problem but find it challenging to choose a problem-solving strategy, and the answers are therefore structurally inconsistent and unsystematic. It seems as though students use haste, carelessness and frequently make trial and error efforts when they attempt to solve problems. Low-performing students have difficulty understanding the problem. In other words, the students' answers in this group were characterized by their low-structure and lack of details. This is clear from the data, as demonstrated by the fact that the students with low grades did not show fluency, flexibility, and originality in creative thinking.

In terms of practice in the subject's curriculum, Jäder et al. (2020) selected and analyzed middle school math textbooks from 12 countries worldwide to learn more deeply about teaching and learning content, resolving mathematics problems. More than 5700 problems have been examined in conjunction with textbook information to determine whether each problem can be solved according to established patterns or if the approach must be built without structure or guidelines. This research data shows that the 12 textbooks included in this study have similar attributes. Specifically, most of the problems can be addressed according to the guided model, and the number of exercises required to build the solution accounts for a significantly low percentage. Thus, the researchers discovered that this emphasizes the necessity of creating textbooks to meet many people's developing problem-solving capacities worldwide. Simultaneously, Saygılı (2017) has shown a crucial role in solving unfamiliar problems in developing students' problem-solving abilities. The described problems require students to understand mathematical concepts and detailed knowledge of the algorithm's process. Research studies have discovered that when students confront problems that they are unfamiliar with, they frequently use innovative approaches to solve them. This training develops problem-solving abilities in students through teaching methods to deal with unknown problems. In terms of assessing problem-solving capacity, Reeff, Zabal, and Blech (2006) outlined a general assessment framework for adult problem-solving capacity assessment (for aged 15 years), emphasizing large-scale assessment requirements. The assessment framework was used as an input in discussions related to international competency studies such as "Program for an International Assessment of Adults' Competencies" (PIAAC) and OECD and could also be used in other studies in the same field. This framework was also considered as the theoretical basis for developing the scale of problem-solving competence level. Karyotaki and Drigas (2016) have the same opinion as Reeff et al. (2006) on assessment tools based on ICT (Information and Communication Technology). According to the them, ICT can assess individuals' ability to solve problems through monitoring and analyzing cognitive and metacognitive processes and their behaviors. The aforementioned computer-based assessment consists of virtual experts with domain knowledge from an automated task-based test, with specific solution strategies combined with log data to identify and analyze the individual's ability to resolve problems

according to specific criteria. In terms of teaching, there are many studies done to target teachers or trainees. Abu and Sayed (2000) performed research to determine the effectiveness of problem-solving strategies on teacher apprentice problem-solving performance. In particular, the study sought to identify the differences between teacher apprenticeship with and without using problem-based strategies. According to the results of the study, using problem-posing strategies for teacher-apprentice learning led to improved performance.

2. THEORETICAL FRAMEWORK

2.1. Problem-solving skill in the Vietnamese General Education Curriculum in Mathematics in 2018

According to this curriculum, math problem-solving skills are demonstrated through the implementation of the following actions:

- Recognize, discover problems that need to be solved by mathematics.
- Propose and choose ways and solutions to resolve the problem.
- Use compatible mathematical knowledge and skills (including tools and algorithms) to cope with problems.
- Evaluate the proposed solution and generalize to the same problem.

Thus, students' problem-solving skills are students' ability to mobilize knowledge, skills, experience, and personal qualities to perform problem-solving activities when faced with learning math problems. The path to seeking a solution is not immediately apparent, and positive confronts the problem.

According to this program, there are specific manifestations of problem-solving skills and requirements that need to be met for junior high school students such as: Firstly, to recognize and detect the problem that needs to be solved mathematically: Detect the problem that needs to be solved; Secondly, choose ways and solutions to address the problem: Identify ways and solutions to resolve the problem; Thirdly, use appropriate mathematical knowledge and skills (including tools and algorithms) to solve problems: Use and present compatible mathematical knowledge and skills to deal with problems; Fourthly, evaluate the proposed solution and generalize to the same problem: Explain the implemented solution.

2.2. Problem-Solving Model

Based on the research and synthesis of problem-solving models in previous studies, the structure of the problem-solving model proposed in this study is described in Figure 1 as follows:

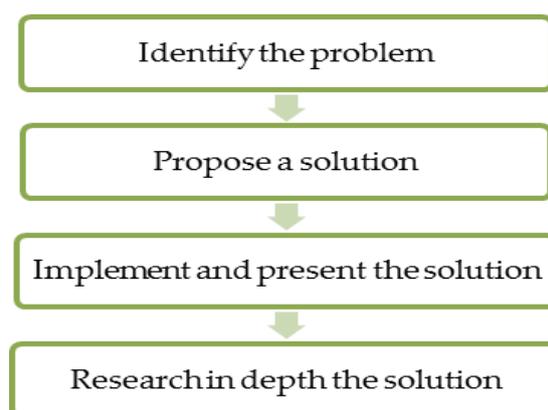


Figure-1. Problem-solving model.
Source: Tong and Han (2020) (personal research)

Step 1: Identify the Problem. In this step, students need to analyze the situation posed in order to identify the problem. For teachers, this step means putting students in a problematic situation. The problem needs to be presented verbally also known as the problem statement.

Step 2: Propose a solution. The purpose of the step is to find different ways to solve the problem. To find solutions to problem-solving, students need to find out and list facts, phenomena, objects, and quantities mentioned in the problem. Students must then rearrange the information appropriately, connect with general knowledge to connect the above information through the formula or compare objects for processing in the next step. If students still cannot find the right option, go back to Step 1 to check if the problem is correct.

Step 3: Implement and present the solution. Of the options proposed in Step 2, students choose an appropriate option to work on to resolve the problem. This option must satisfy the problem-solving requirement and be more optimized than the other alternatives (faster problem-solving, more straightforward solutions, fewer chances of error). Moreover, students need to present solutions closely and clearly. If the planned results are not appropriate or the answer is not feasible, students must check Step 2 to see if the option was reasonable. Once students have chosen the appropriate plan and found the right result, the problem-solving ends here.

Step 4: Research in depth the solution. This step aims to explore the possible applicability of results or propose new related problems by considering similarity, generalization, and problem reversing. At the lower secondary level, students need to explain the selected option.

2.3. Evaluating Problem-Solving Skills

Students' problem-solving skills are evaluated using the criteria in Table 1 as follows:

Table-1. Evaluation criteria of problem-solving skills.

Component capacity	Evaluation criteria
1. Ability to detect problems	Find out, determine the problem to be solved
	+ Wrong problem definition (0 points)
	+ Not fully understanding the problem, and small flaws (1 point)
	+ Correct understanding (2 points)
	Collect information related to the problem (list mathematical facts and figures related to the problem)
	+ Incomplete and incomplete collection (0 points)
	+ Information was collected but incomplete and inaccurate (0.5 points)
2. Ability to propose solutions	+ Collect information fully and accurately (1 point)
	Convert given problem information to the mathematical model
	+ Contact relevant knowledge and information (1 point)
	+ Express the problem in the mathematical language (1 point)
	Find a solution to solve math problems
	+ Wrong, ineffective solution (0 points)
	+ Correct solution, but with small flaws (0.5 points)
3. Ability to solve problems	+ Correct and detailed solution (1 point)
	+ Wrong calculation (0 points)
	+ Correct calculation, but the solution method and the tool are not optimal (1 point)
4. Ability to evaluate performance results	+ Correct calculation and tools, optimal solution method (2 points)
	Review and select results (1 point)
	Answer the request of the problem (1 point)

Source: Tong and Han (2020) (personal research)

On that basis, the achievement level of students' problem-solving competencies is evaluated, as shown in Table 2.

2.4. The First-Degree Equations in One Unknown in the Vietnamese Math Textbook

The Math 8 textbook of Vietnam states the definition of a first-degree equation in one unknown as follows: An equation in the form $ax + b = 0$ with a and b being two given numbers and $a \neq 0$ is a *first-degree equation in one unknown*. Next, the textbook adds the transposing and multiplying rules in the process of solving the above

equation. First, the transposing rule is "In an equation, we can move a term from one side to the other side and change its sign." Meanwhile, the multiplying rule is possible to multiply both sides of an equation by a non-zero number. There is a belief that this approach will not support students in developing problem-solving competence because most of the concepts and rules they are exposed to are informative.

Table-2. Ranking of problem-solving skill assessment.

Score	Classification	Note
From 1 point → less than 5 points	Weak	Not applicable
From 5 points → less than 6.5 points	Medium	.Not applicable
From 6.5 points → less than 8 points	Good	The criterion for converting given problem information about the mathematical model does not reach 1 point, or the criterion for solving the math problem does not reach 2 points.
From 8 points → 10 points	Very good	The criterion for converting given problem information about the mathematical model gets 1 point, and the criteria for solving math problems reach 2 points.

Source: Tong and Han (2020) (personal research).

It can be said that the topic of solving problems by setting up equations is real-world problems. Every situation in life provides problems, and students must solve them mathematically to meet those needs. The first step for students to become familiar with how to address these problems. The textbook offers three activities, namely: Activity 1, to represent the quantities by algebraic expressions; Activity 2, an example of solving problems; and Activity 3, a summary of the steps for solving a problem by making an equation. Other than that, the textbook provides step-by-step instructions on how to handle the problem by setting up the equation.

Step 1: Set up an equation: Choose an unknown and put an adequate restriction on the unknown; represent unknown quantities in the unknown and the quantities that have been known; and set up an equation expressing the relation of quantities.

Step 2: Solve the equation: Proceed with application of the equation.

Step 3: Answer: Check which of the solutions to the equation does meet the restriction on the unknown, which does not and then conclude.

This type of task is divided into several forms, including motion problems, problems of finding a number, problems of calculating the cost of goods, productivity problems, and problems of geometric factors. While this can be said, one must take into consideration the teaching of students to be able to handle problems that occur in two distinct stages: Stage 1 is to get used to making formulas and algebraic expressions showing relationships between quantities; Stage 2 is to choose two equal quantities to form an equation and resolve. Vietnamese textbooks have consolidated background knowledge based on the problem-solving teaching model to lead to flexibility and creativity in problem-solving strategies. Nevertheless, these skills can hardly be formed with a small amount of exercise or practice; This can lead to difficulties for students, causing fear when having to solve the exercises by setting up equations (the ability to connect events is not right, the training in stage 1 is not enough to through stage 2).

2.5. Research Goal and Questions

While first-degree equations in one unknown are undoubtedly a practical issue to learn about and develop problem-solving skills for students, this topic contains many real-world problems found on reality shows. For this reason, the primary objective of this research is to provide 8th graders with the skills required to approach the first-

degree equations in one unknown as a problem to be resolved. Research to investigate the following questions is done to test whether additional research on the aforementioned subjects is possible.

1. What do students learn about the first-degree equations in one unknown?
2. When students learn about the real-world problems related to the first-degree equations in one unknown, how will they improve their mathematical knowledge?
3. How did students develop their problem-solving skills after they participated in the learning process above? Do they have any difficulty in resolving the problems?
4. What is students' attitude when they handle real-world problems involved with the first-degree equations in one unknown?

3. METHODOLOGY

3.1. Participants

The experimental research was conducted on a sample of 41 students from grade 8A8 and 41 students from grade 8A1 from An Thoi middle school, Binh Thuy district, Can Tho city, Vietnam. The class 8A8 was the experimental class and class 8A1 was the control class. The analysis of the grade point average of mathematics in the final test of the first semester showed that students in these two classes had similar proficiency levels. Students had learned about the first-degree equations in one unknown. Several experiments were performed to solve problems by setting up equations to better train students' problem-solving abilities. To guarantee the quality of teaching practice, we selected participants who were both available and interested in learning. Besides, the study discovered that students' prejudice and disrespect were not a part of the study, which means those students may have been subjected to any harm this absence of inclusion might have caused.

3.2. Research Design

Experiments were conducted throughout the lesson to figure out how to solve the problem by setting up equations. In the experimental process, for grade 8A8, teachers taught situations that had been designed to develop problem-solving abilities and conducted traditional lessons for class 8A1. The empirical sequence of pedagogy is shown in Table 3.

Table-3. Pedagogical experimental sequence for experimental and control classes.

Group	Pre-test	Intervention	Post-test
Class 8A8 (experimental group)	Semester I test	X	X
Class 8A1 (control group)	Semester I test	---	X

Source: Tong and Han (2020) (personal research).

The quasi-experiment was done in the same way as done by Yuberti, Anugrah, Saregar, Misbah, and Jermisittiparsert (2019). The process of impacting the experimental class is shown in Figure 2 :

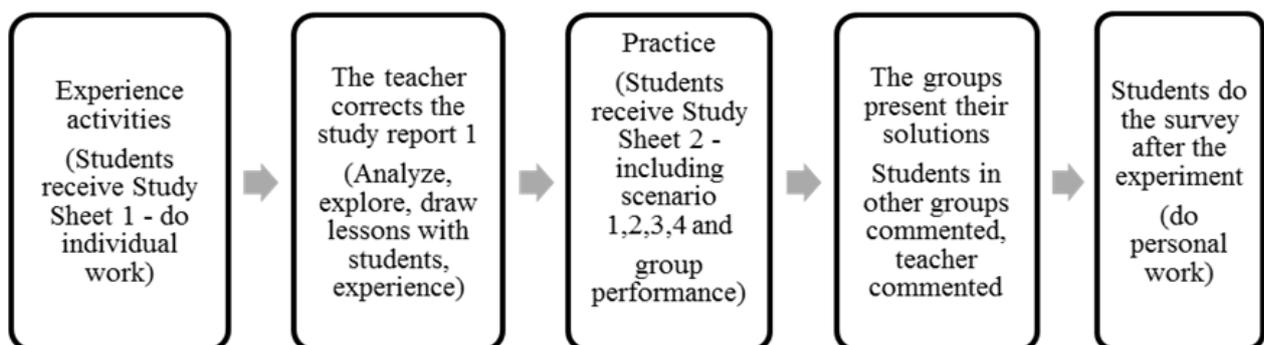


Figure-2. Process of affecting the experimental group of grade 8A8.

Source: Tong and Han (2020) (personal research).

i. The contents of Study Sheet 1 are as follows:

Problem: "Two people go from A to B; the first person travels at 40 km / h, the second person travels at 25 km / h. To go all the way to AB, the first person needs 1 hour and 30 minutes less than the second person. Calculate distance to AB."

1. What kind of problem? What does the problem require to find? List quantities and a formula for the relation between them.

2. What information does the problem provide? Make a summary as shown below. Thereby, what quantity will you call x for? What quantity will you rely on to create an equation?

3. Present the solution.

4. In your opinion, does the solution satisfy the conditions of the problem? Do you have any other way to solve this problem?

ii. Study sheet two consists of four problems designed as follows:

Problem 1: A planned production team must produce 50 products per day. When implementing, the team produced 57 products a day. Therefore, it completed one day ahead of schedule and even exceeded 13 products. How many products does the team have to produce according to the plan?

Problem 2: Friend Huy bought 20 notebooks. Suppose each notebook costs twice as much as the volume of the notebook. Each notebook costs 12000 VND. How many notebooks did Huy buy? Note that he paid a total of 336000 VND.

Problem 3: The teacher has some candies and wants to divide them into small gift bags. If she divides each gift bag by five candies, she will get more gift bags when dividing each gift bag with eight candies, which is three bags. How many candies does the teacher have at first?

Problem 4: If a rectangle has a circumference of 372 m and the length increases by 21 m, and the width is 10 m, the area increases by 2862 m². Calculate the size of the rectangle at first?

After completing the lesson, students from two experimental and control classes perform the output survey with the following content:

Problem: the grade 8A8 teacher plans to buy a car ticket for his class's students on a field trip. The teacher is wondering between two passenger car companies, Phuong Nam and the East Sea.

+ Phuong Nam car company collects 200000 VND for each student.

+ Bien Dong car company collects a fixed fee of VND 2 million and an additional 150000 VND per student.

Note that the total cost of the two-car manufacturers is equal. How many students does 8A8 have, and how much does it cost to buy tickets for the tour?

Students fulfill the following requirements:

1. What kind of problem? What does the problem require? Which quantities are included? What is the formula of the relation between quantities?

2. Make a summary sheet. Thereby expected equations are established.

3. Solve the problem.

4. Consider and select the results to answer the initial problem.

Additionally, the survey after the experiment was conducted to assess the students' attitudes in the practical lessons. Students chose one of the following five levels of content for each item: Strongly disagree - disagree - neutral - agree - strongly agree. The content of the survey item was as follows:

1. I like this lesson.

2. I can keep track of all the content of each activity in class.

3. I want to learn the classes I have today.

4. I know how to do the same exercises.

5. I understand all of the lessons.

3.3. Collecting and Analyzing Data

A paired t-test test was run based on students' first-semester test scores to examine the two classes' equivalence, the experimental and the control, selected as subjects for this study. Post-test results and exam papers were collected and analyzed to evaluate students' problem-solving abilities. The reliability of the data was examined in depth in accordance with Yuberti et al. (2019). Specifically, the methods of quantitative and qualitative analysis were applied as follows:

Quantitative assessments were used for post-test results to demonstrate the effectiveness of experimental effects. The paired t-test method hypothesized that students' average score in the experimental class was higher than the control class's average score.

Qualitative Assessment: Table 1 described the different evaluation criteria. A scale of 10 was assigned to the student's work based on the table's criteria. Then, the assessment was based on this score and the classification levels in Table 2 to assessed the capacity to address students' problems when solving real-world problems.

Attitude assessment: The results were collected through observing students' attitudes in the lesson and conducting interviews to survey students after the experimental period. The survey items were designed based on the Likert scale with five levels: Strongly disagree - disagree - neutral- agree - strongly agree.

4. FINDINGS AND DISCUSSIONS

4.1. Pre-Test Results

To verify the level equivalence of the experimental and control classes, semester I test scores of grades 8A1 and 8A8 were analyzed and used in the paired t-test as follows:

Let X be the grade 8A8, μ_X the average score of the student in grade 8A8.

Let Y be the grade 8A1, μ_Y the average grade of the student in grade 8A1.

Select hypothesis H0: $\mu_X = \mu_Y$ (that is, students' learning results in two classes were equivalent). The hypothesis H1: $\mu_X \neq \mu_Y$ (meaning that students' learning results in two classes were not equivalent).

Table-4. The average scores of the control class and the experimental class.

Class 8A8	Class 8A1	d_i	d_i^2
253.6	255.3	-1.7	6.01

Source: Tong and Han (2020) (personal research).

Based on the data from Table 4, $\bar{d} = \frac{\sum d_i}{n} = \frac{-1.7}{41} = -0.041$; $s_d = \sqrt{\frac{\sum d_i^2 - (\sum d_i)^2/n}{n-1}} = \sqrt{\frac{6.01 - (-1.7)^2/41}{41-1}} = 0.38$,

and t value, $t = \frac{\bar{d}}{s_d/\sqrt{n}} = \frac{-0.041}{0.385/\sqrt{41}} = -0.682$.

With a significance level, $\alpha = 0.05$, 40, the TINV (0.05,40) function in Microsoft Excel was used to find the critical value $t_{0.025} = 2.02$. Therefore, the rejection domain was $(-\infty; -2.02) \cup (2.02; +\infty)$. The value $t = -0.682$ was not in the rejection domain, so H1 was rejected and H0 accepted. Thus, the learning results of students in grades 8A1 and 8A8 were equivalent.

4.2. Worksheet Results

The following were the results obtained from analyzing student work in Study Sheet 1:

Question 1: What kind of problem is the problem? (Hints: Motion, productivity, billing, grouping) What does the problem require? What quantities are there? What is the formula of the relationship between quantities? Students looked to see if there was a hint in order to answer this question. On the other hand, students responded to these statements, with 61.7% students responding with a full and correct response, while 29.7% of students stated that they lacked the formula for the relation between quantities; and 8.5% of students responded with an incomplete or incorrect answer. Overall, students found that most problems could be identified and that most problems could be resolved with the correct amount of previously learned knowledge and familiarity with the correct name and meaning of the quantity. Figure 3 showed the exact results for one student.

- Bài toán thuộc dạng chuyển động.
 - Cần tìm quãng đường AB.
 - Có các đại lượng: s, v, t
 - Công thức: $s = v \cdot t \mid v = \frac{s}{t} \mid t = \frac{s}{v}$

Figure-3. Student 14's worksheet with the correct answer.
 Source: Tong and Han (2020) (students' worksheet collection).

Question 2: What information does the problem show? Make a summary sheet. Hint: what should x be called? Represent unknown quantities in x and known quantities. Based on the relationship, which quantity to make an equation for? When students were given the test and surveyed afterward, 48.8% answered the question correctly, 51.2% of the remainder could determine the quantity value but failed to answer the final question. While most students could convert information into mathematical models and connect them with formulas, only a small minority was proficient in the process. Nonetheless, not all students could identify critical information used to construct the equation, resulting in the students getting lost while solving mathematical problems. A complete solution is illustrated in Figure 4.

	v	t	s
Người I	40	$\frac{x}{40}$	x
Người II	25	$\frac{x}{25}$	x

..... $t_I < t_{II} : 1,5 \text{ giờ}$

..... $\Rightarrow \frac{x}{25} = \frac{x}{40} + 1,5$

Figure-4. Student 14's worksheet with the correct answer.
 Source: Tong and Han (2020) (students' worksheet collection).

Question 3: Based on the summary table and expected equation, solve the problem. This demonstrates that 46.3% of students were able to set up the equation and solve the equation correctly. In Figure 5, we see the solution that provided full resolution. A majority of the students were confused because the class section had no direction for the remaining students. When one student incorrectly handled the problem due to a calculation error, another student addressed the correct equation. According to statistical data, it appears that nearly half of the students did not have an equation.

- coi quãng đường AB là x (~~$x > 0$~~) (km) ($x > 0$)
 - thời gian người I đi là: $\frac{x}{40}$ (h)
 - thời gian người II đi là: $\frac{x}{25}$ (h)
 - do thời gian người I đi ít thời gian hơn người II nên ta có pt:

$$\frac{x}{25} - \frac{x}{40} = 1,5 \text{ giờ}$$

$$\Rightarrow 8x - 5x = 300$$

$$\Rightarrow 3x = 300$$

$$\Rightarrow x = \frac{300}{3} = 100 \text{ (nhân)}$$

Vậy quãng đường AB là 100km

Vậy quãng đường AB là : 100 km

Figure-5. Student 20's worksheet with the correct answer.
 Source: Tong and Han (2020) (students' worksheet collection).

Question 2 was a sign that pointed to the answer to Question 3. When students worked with the table, they were able to make connections, like saying that the problem's known values were velocity quantity, had all known values, and was unable to name the pronouns' amount of time and distance. Therefore, when trying to represent those unknown quantities, the students needed to use x instead of a value for a quantity, where most students chose to call x the value to be found the distance AB . Then, the summary in the table showed the values of two quantities, using the formula of the relationship between the quantities $s = v \times t$ to deduce time $t = s : v$. Finally, only the information "To go all the way AB , the first person needs 1 hour and 30 minutes less than the second", students would base on the relationship between two values of the same quantity time to create the equation.

Question 4: Comment on the solution of the equation. Do you have any other way to solve this problem? According to statistics, approximately 25 students (60.1% of the class) used statistics to identify and compare possible solutions with the problem's conditions. Furthermore, none of the problem solutions changed any of the conditions. Study cards were designed in a step-by-step problem-solving order to support students in familiarizing themselves with approaching problems, detecting problems, and settling problems effectively. Although the groups' results were quite good, it was observed that some students, who did not know how to convert information into mathematical formulas, took a long time to determine the necessary equations. This was the most significant difficulty for the students, as they had no prior experience of solving equations. While solving the equation in problems 1, 2, and 3 was straightforward, students were unable to find the appropriate use of perimeter data when presented with problem 4, and their request for additional operations made resolving the equation more complicated. Research by the authors Saleme and Etchells (2016) also showed students' facing same difficulties when solving problems.

Observing their work progression and the results revealed the ability to discern when students had obtained valuable information from their study cards and whether they had resolved math more efficiently. The questions were challenging, but in particular, it was still possible for the average student to respond to them. Converting information into mathematical formulas and summarizing with tables aided students learn the information and better understand what they needed to accomplish before moving on to equations. As illustrated in Figure 6, the correct solution for group 14 was provided.

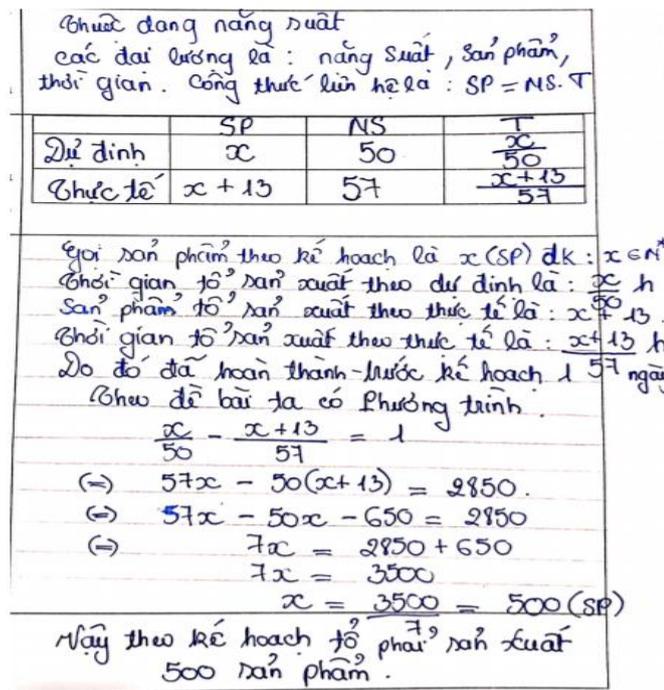


Figure-6. Group 14's worksheet with the correct answer. Source: Tong and Han (2020) (students' worksheet collection).

From this, it follows that the following conclusions can be drawn by solving problems through building equations. First, students would need to learn the process of solving a problem, then practice this to acquire the necessary skill for problem-solving through the use of a systematic approach that incorporates stages. Second, students created and solved equations when they were actively involved, had ample resources, and understood the relevant information; their conclusions were clear because of the formula, and they used the summary table to identify the problem's hypotheses and requirements. There were some students, however, who still found it challenging to make the information contained in algebraic expressions translate into the variable x , who was not proficient at connecting information to establish equations. Furthermore, the experimental results proved that group activities in the practice period create learning opportunities for students by allowing them to observe, recognize, and overcome shortcomings and comprehend questions asked by their classmates.

4.3. Post-Test Results

4.3.1. Quantitative Analysis

Test results were scored on a 10-point scale, and the statistics were shown in Table 5.

Table-5. Statistics of test scores of 8A8 and 8A1 classes.

Score	0 - 3.4	3.5 - 4.9	5.0 - 6.4	6.5 - 7.9	8.0 - 10.0	Average Score	Total
Class 8A8	1	0	3	8	23	7.4	41
Class 8A1	17	0	8	4	12	4.6	41

Source: Tong and Han (2020) (personal research).

The experiment's conclusion could be determined by testing the hypothesis that the average score of the experimental class was higher than the control class's average score using the t-test method, which served to verify the practical intervention's effectiveness. To analyze the above results as follows:

Let X be the experimental grade, μ_X the average grade of the student in the experimental class.

Let Y be the control's score, μ_Y the average score of the student in the control class.

Select hypothesis H0: $\mu_X = \mu_Y$ (meaning there was no difference between students' learning performance in experimental and control classes). The hypothesis H1: $\mu_X > \mu_Y$ (meaning that students' learning efficiency in experimental class was higher than that of the control class).

Table-6. Sample data of the scores of classes 8A8 and 8A1.

Class 8A8	Class 8A1	d_i	d_i^2
304.3	189	115.3	492.39

Source: Tong and Han (2020) (personal research)

According to the data in Table 6, $\bar{d} = \frac{\sum d_i}{n} = \frac{115.3}{41} = 2.81$; $s_d = \sqrt{\frac{\sum d_i^2 - (\sum d_i)^2/n}{n-1}} = \sqrt{\frac{492.4 - (115.3)^2/41}{41-1}} = 2.05$.

and value t , $t = \frac{\bar{d}}{s_d/\sqrt{n}} = \frac{2.81}{2.05/\sqrt{41}} = 8.777$.

With significance level $\alpha = 0.05$, degree 40, the TINV function ($2 * 0.05, 40$) in Microsoft Excel was used and found the critical value $t_{0.05} = 1.68$, so the rejection domain is $(1.68; +\infty)$. The value $t = 8.777$ was in the rejection domain, so H0 was rejected, and the H1 was accepted. Thus, students' learning efficiency in the experimental class was higher than that of students in the control class.

4.3.2. Qualitative Analysis

The student's test was scored on a 10-point scale based on the criteria in Table 1. Based on these scores and Table 2, assessments of students' problem-solving abilities could be made. Results were shown in Table 7.

Table-7. Statistics of the results of students' problem-solving skills.

	Classification	Very good	Good	Medium	Weak
8A8	f	27	5	1	8
	%	65.9	12.2	2.4	19.5
8A1	f	12	4	4	21
	%	29.3	9.8	9.8	51.2

Source: Tong and Han (2020) (personal research).

A fact like this is supported by the data found in Table 7, which shows that 65.9% of students could deal with problems at a reasonable level. Specifically, students could identify the problem to be solved, know how to convert from the original problem's information to the mathematical model, and propose solutions and present solutions for good. On the whole, the number of average students and the number of attractive students were reasonably low. Nonetheless, nearly 19.5% of the students were still underdeveloped. The main reason was that they had not gathered accurate and comprehensive information, did not comprehend the significance of data in the problem, and could not convert information from a given problem to a mathematical model. Although many good assignments accomplished the goal of systematizing the numbers and discovering relationships between the quantities, most of these assignments did an exceptional job of these tasks.

Additionally, it may be useful to make conclusions regarding some specific competencies of students, as follows. First, students' abilities to find problems and gather information about them from experiments were impressive. For one thing, students came up with the essential information surrounding the real-world problem. When they attempted to answer the problem, most students concluded that the problem was identifying the question. The exercises that displayed exceptional results had exercises with clear sentence-building, demonstrating their ability to learn the problem very well. Farida et al. (2018); Karyotaki and Drigas (2016); Simamora et al. (2017) have few studies on the relationship between the theory of realistic mathematics education (RME), problem-based teaching

(PBL) and problem-solving and had made similar conclusions about the importance of real-world problems in teaching that developed students' problem-solving skills. Figure 7 presents this phenomenon as seen in student 01's worksheet with the correct answer.

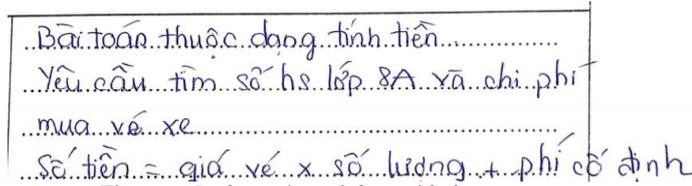


Figure-7. Student 01's worksheet with the correct answer.
Source: Tong and Han (2020) (students' worksheet collection).

Furthermore, to be able to find a problem-solving strategy, like, for instance, converting information about the mathematical model and relating the quantities, there were eight weak ratings, with most of the points being given to students for being unable to reduce the thousands to the hundreds to get rid of the zeros. Even though many students did not know how to represent the quantity, they still understood the fixed cost of a South China Sea vehicle, which resulted in the student failing to create a quantity relationship. Figure 8 is an evidence of this as reflected in student 09's worksheet with the correct answer.

công ty	độ tiền (đồng)	đơn giá (đồng)	số người
Phiên nguyên	200.000 x	200.000	x
Phiên Đem Điền đồng	200000 + (150000 x)	150.000	x

Figure-8. Student 09's worksheet with the correct answer.
Source: Tong and Han (2020) (students' worksheet collection).

Moreover, students should be able to figure out what the problem's requirement is and how each quantity relates to it in terms of problem-solving capacity. For most students, knowing the properties of a mainly known quantity would suffice to write an equation and solve a correct equation, as long as it was representing an unknown quantity. Many students were able to write formulas and identify quantities but were unable to write equations further supported this theory. On the whole, average student work consisted of incomplete work summaries. The assessments were made on exercises that had completed a summary sheet but could not correctly write equations.

Fourth, it was demonstrated by the exercise, which resolved the equation that the evaluation capacity had been expanded. It was observed that the only way to know the value of x was to go on and look for the amount of the ticket. Additionally, not the best result was reached because car tickets were bought for 8000 VND when that sum was multiplied by 8 million VND to convert to the local currency, which produced a loss of 600000 VND.

4.4. Assessing Students' Attitude

The following were the results of the analysis of the survey items of 41 experimental students.

- i. Item 1: I like this lesson.

Table-8. The answer statistics of Item 1.

Level	%
Strongly like	29.3
Like	36.6
Neutral	34.1
Dislike	0
Strongly dislike	0

Source: Tong and Han (2020) (personal research),

Table 8 shows that more than 50% of the students liked this class, and no students said they did not like it. Students of all ages enjoyed classroom excitement. Therefore, the organization of games such as "checking board with teachers", "Flip" (held in practical lessons) not only brought joy to students in the class but also helped teachers achieved pedagogical goals through games. Furthermore, the learning activities that required students to work individually, work in groups continuously, and record students' work on the report cards helped them realize the central role of their efforts and work results recognized in forming new knowledge.

ii. *Item 2: I can keep track of all the content of each activity in class.*

Table-9. The answer statistics of Item 2.

Level	%
Strongly agree	36.6
Agree	48.8
Neutral	14.6
Disagree	0
Strongly disagree	0

Source: Tong and Han (2020) (personal research).

This can be found in Table 9, where 85.4% of the students felt they were capable of keeping track of the activities and tasks the teacher had. This number contributed to reinforcing the previous conclusion to the results of Item 1. By monitoring and experiencing the lesson's progress, students could understand and remember more deeply; this was also what the teacher wanted. With two lessons in class, it was impossible to expect all students to apply the lessons well to solving problems by building equations instead of doing experiments to help students determine directions and address similar problems. This was an initial favorable outcome for the implementation of the research goal.

iii. *Item 3: I want to learn the classes I have today.*

Table-10. The answer statistics of Item 3.

Level	%
Strongly agree	24.4
Agree	36.6
Neutral	34.2
Disagree	9.8
Strongly disagree	0

Source: Tong and Han (2020) (personal research).

According to survey results, approximately sixty percent of students wanted to take the same classes (see Table 10). Besides, there were still some students who wanted to take the same classes as before. First, the statistical results of Item 1 and Item 2 partly explained most students' choices. The remaining students' choices could be explained through several limitations observed in the classroom: First, some students did not actively cooperate with the teacher mobilization. Second, some students did not participate well in group activities; this could be because they were not familiar with cooperative activities due to personality traits or confidence. Third, some children were used to passive learning activities; this was also why students had not adapted to the lessons that required them to be active. Nevertheless, teachers could overcome the above limitations by designing and organizing teaching to develop problem-solving capacity based on combining appropriate pedagogical measures.

iv. *Item 4: I know how to do the same exercises.*

The data in Table 11 shows that 85.4% of students say that they can solve a problem by creating an equation, over 62.8% believe they can. This figure showed the effectiveness of activities designed to assist students in mastering the process of solving mathematical problems. On the other hand, the above results showed that students had confidence in their understanding of knowledge - this was one factor that creates capacity. At the same time,

these results were similar to some studies by Behlol et al. (2018); Ersoy (2016); Osman et al. (2018); Ozreçberoglu and Çağanağa (2018); Saygılı (2017).

Table-11. The answer statistics of Item 4.

Level	%
Strongly agree	29.3
Agree	24.4
Neutral	31.7
Disagree	14.6
Strongly disagree	0

Source: Tong and Han (2020) (personal research).

Besides, 14.6% of students thought that it was uncertain that they could resolve similar problems. This result could be because some students found that their math performance was not right, and they still had many difficulties in solving tasks, so they were not confident in themselves. However, based on the statistical results from items 1, 2, and 3, it could be confirmed that students would reinforce their knowledge, skills and had a more positive attitude in problem-solving with appropriate learning and practice methods.

v. *Item 5: I understand all of the lessons.*

Table-12. The answer statistics of Item 5.

Level	%
Strongly agree	34.2
Agree	46.3
Neutral	19.5
Disagree	0
Strongly disagree	0

Source: Tong and Han (2020) (personal research).

Statistical results in Table 12 show that 80.5% of students fully understood practical lessons' content, including students with abysmal performance. This result meant that active learning activities engaged students in knowledge-forming tasks. Although some students still made mistakes, they saw each task's purpose and meaning through it. At the same time, the above results showed a student's focus on lessons. This data was consistent with the statistical results of Item 2: Only when students go through a discovery - practice activity, they could learn from other experiences or remember experiences with others; they solved the obstacles before, to understand how to cope with problems.

5. CONCLUSION

Having discussed how to teach problem-solving by setting up equations, it is concluded that students should apply the process of solving problems through experiential activities and practice step by step instead of focusing on the solving step. Algebraic math problems were difficult for students to get used to, and equations were an added complication. Moreover, students were able to create equations and solve them when considering relevant knowledge, to clearly see the relationship between the quantities through the formula and use the pseudo-determination summary required and the task to be performed. Furthermore, group activities also created opportunities for students to learn from each other, overcome their weaknesses, and strengthen their understanding of the problem from classmates' questions. Nonetheless, some students still had difficulty in recognizing problems, converting information into algebraic forms, not proficient in setting up equations, knowing the information well but not connecting the information yet to create an equation.

Thus, after the experimental class received the pedagogical impacts towards problem-solving capacity development, the component competencies such as the capacity to explore the problem, collect information from the

practical situations; the ability to convert information from practical situations about the mathematical model; capacity to seek strategy for solving mathematical models; the ability to execute solving strategies to find results. The student's ability to change from solving mathematical models to addressing real-world problems had significantly improved compared to the situation before the experiment (when students solved problems in experimental activities). Additionally, students demonstrated considerable leadership and initiative in making plans, working together, and developing novel solutions to problems. The above results showed that the proposed measures were useful, contributing to the development of problem-solving capacity and stimulating the spirit and sense of learning for students. This result could confirm the feasibility and effectiveness of the study.

On the other hand, experimental results showed that real-world problems played an essential role in developing students' problem-solving abilities. Therefore, real-world problems must be incorporated into the teaching curriculum, as this expands the previous statement. The first was because the problems associated with reality were considered unfamiliar problems; as mentioned earlier, this was the kind of problem that could promote students' problem-solving abilities. The second reason, the ultimate goal of math education, was to help students apply the appropriate knowledge and skills to address real-world problems. The use of practical problems in teaching, on the one hand, helped students develop their ability to settle problems; on the other hand, it also assisted them to see the relationship between mathematics and life and the meaning of knowledge they had learned.

This study's final result motivated students to be more enthusiastic about learning and made them want to discover and fix the lesson's problems. Simultaneously, based on the established mathematical belief, it was possible to stimulate students' interest in solving real-world problems through mathematical tools.

Given the importance of problem-solving capacity through mathematics, the problem-solving capacity development has become one of the essential teaching methods of the 21st century (Ocak, Eđmir, 2014; cited in Ozreçberoglu and Çađanađa (2018)). Thus, it is imperative to have comprehensive problem-solving measures to implement in teaching practices. Firstly, teachers need to be trained, fostered, or their knowledge of applying problem-solving honed voluntarily in teaching. In other words, teaching should be done in the direction of developing problem-solving skills. Even in the pedagogical training stage, it is necessary to have specialized problem-solving subjects to develop pedagogical students' skills to solve problems, think, apply, and positively assess them (Ersoy, 2016). Thus, students will receive education about problem-solving solutions in a much more thorough and efficient manner. The second thing is that the textbook should be designed in a way that incorporates problem-solving activities. By encouraging teachers to act as mentors, this approach also enables teachers to implement new teaching methods. Additionally, educational institutions and schools should develop favorable learning conditions that enable the distribution of curricula and the time and facilities needed to implement teaching methods and develop solutions to the problem.

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REFERENCES

- Abu, R., & Sayed, E. E. (2000). Effectiveness of problem-posing strategies on prospective mathematics teachers' problem-solving performance. *Journal of Science and Mathematics Education In S.E. Asia*, 14(1), 56-69.
- Angateeah, K. (2017). An investigation of students' difficulties in solving non-routine word problem at lower secondary. *International Journal of Learning and Teaching*, 3(1), 46-50.
- Behlol, M. G., Akbar, R. A., & Sehrish, H. (2018). Effectiveness of problem-solving method in teaching mathematics at elementary level. *Bulletin of Education and Research*, 40(1), 231-244.
- Cockcroft, W. H. (1982). *Mathematics counts: Report of committee of the inquiry into the teaching of mathematics in schools*. London: HMSO, 1-311.

- Collins, A. (2012). What is the most effective way to teach problem-solving? A commentary on productive failure as a method of teaching. *An International Journal of the Learning Sciences*, 40(4), 731-735. Available at: <https://doi.org/10.1007/s11251-012-9234-5>.
- Ersoy, E. (2016). Problem solving and its teaching in mathematics. *The Online Journal of New Horizons in Education*, 6(2), 79-87.
- Farida, N., Bagus, A. S., & Maya, R. R. (2018). Students' problem-solving ability based on realistic Mathematics with ethnomathematics. *Journal of Research and Advances in Mathematics Education*, 3(1), 13-24.
- Granberg, C. (2016). Discovering and addressing errors during mathematics problem-solving – a productive struggle? *Journal of Mathematical Behavior*, 42, 33-48. Available at: <https://doi.org/10.1016/j.jmathb.2016.02.002>.
- Greiff, S., Holt, D. V., & Funke, J. (2013). Perspectives on problem-solving in educational assessment: analytical, interactive, and collaborative problem-solving. *The Journal of Problem Solving*, 5(2), 71-91. Available at: <http://dx.doi.org/10.7771/1932-6246.1153>.
- Guzman, G. M. (2018). Mathematical problem-solving strategies among student teachers. *Journal on Efficiency and Responsibility in Education and Science*, 11(3), 53-64. Available at: <https://doi.org/10.7160/eriesj.2018.110302>.
- Hoon, T., Kee, K., & Singh, P. (2013). Learning mathematics using heuristics approach. *Procedia - Social and Behavioral Sciences*, 90, 862-869. Available at: <http://dx.doi.org/10.1016/j.sbspro.2013.07.162>.
- Jäder, J., Lithner, J., & Sidenvall, J. (2020). Mathematical problem solving in textbooks from twelve countries. *International Journal of Mathematical Education in Science and Technology*, 51(7), 1120-1136.
- Karyotaki, M., & Drigas, A. (2016). Latest trends in problem solving assessment. *International Journal of Recent Contributions from Engineering, Science & IT (iJES)*, 4(2), 4-10. Available at: <https://doi.org/10.3991/ijes.v4i2.5800>.
- Kaur, B. (1997). Difficulties with problem solving in mathematics. *The Mathematics Educator*, 2(1), 93-112.
- Lai, Y., Zhu, X., Chen, Y., & Li, Y. (2015). Effects of mathematics anxiety and mathematical metacognition on word problem-solving in children with and without mathematical learning difficulties. *Plos One*, 10(6), 1-19. Available at: <https://doi.org/10.1371/journal.pone.0130570>.
- Lester, F. K., Garofalo, J., & Kroll, D. L. (1989). Self-confidence, interest, beliefs, and metacognition: Key influences on problem-solving behaviour. In D.B. McLeod, & V.M. Adams (Eds.) *Affect and mathematical problem solving: A new perspective* (pp. 75-88). NY: Springer-Verlag.
- Liljedahl, P., Santos-Trigo, M., Malaspina, U., & Bruder, R. (2016). Problem solving in mathematics education: Springer Open, ICME-13, Hamburg, Tropical Surveys. Available at: <https://doi.org/10.1007/978-3-319-40730-2>.
- London, R. (1993). A curriculum of non-routine problems (pp. 1-44). Atalanta: American Educational Research Association.
- Nafees, M. (2011). *An experimental study on the effectiveness of problem-based versus lecture-based instructional strategy on achievement, retention and problem solving capabilities in secondary school general science students*. Ph.D. Unpublished Thesis, International Islamic University, Islamabad.
- Osman, S., Che, Y. C. N. A., Abu, M. S., Ismail, N., Jambari, H., & Kumar, J. A. (2018). Enhancing students' mathematical problem-solving skills through bar model visualisation technique. *International Electronic Journal of Mathematics Education*, 13(3), 273-279. Available at: <https://doi.org/10.12973/iejme/3919>.
- Ozreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making it count: Strategies for improving problem-solving skills in mathematics for students and teachers' classroom management. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(4), 1253-1261. Available at: <https://doi.org/10.29333/ejmste/82536>.
- Polya, G. (1988). *How to solve it: A new aspect of mathematical method* (2nd ed.). Princeton, NJ: Princeton University Press.
- Reeff, J. P., Zabal, A., & Blech, C. (2006). The assessment of problem-solving competencies. A draft version of a general framework. Retrieved from http://www.die-bonn.de/espid/dokumente/doc-2006/reeff06_01.pdf.
- Saleme, Z., & Etechells, M. J. (2016). A case study: Sources of difficulties in solving word problems in an international private school. *Electronic International Journal of Education, Arts, and Science*, 2(Special Issue), 149-163.
- Saygılı, S. (2017). Examining the problem solving skills and the strategies used by high school students in solving non-routine problems. *E-International Journal of Educational Research*, 8(2), 91-114.

- Schoenfeld, A. H. (1992). Learning to think mathematically: Problem-solving, metacognition, and sense-making in mathematics. In Grouws, D., (Ed.), Handbook of research on mathematics teaching and learning (pp. 334-370). New York: MacMillan.
- Sidenvall, J. (2019). Literature review of mathematics teaching design for problem solving and reasoning. *Nordic Studies in Mathematics Education*, 24(1), 51-74.
- Simamora, R. E., Sidabutar, D. R., & Surya, E. (2017). Improving learning activity and students' problem solving skill through problem based learning (PBL) in junior high school. *International Journal of Sciences: Basic and Applied Research*, 33(2), 321-331.
- Syahrole, A., Saman, A., Kin, S., & Chin, K. E. (2016). *A model for mathematics problem-solving*. Paper presented at the Conference: Proceedings of The International Conference on Education and Higher Order Thinking Skills 2016. At: UTM Johor, 1.
- Tong, D. H., & Han, N. N. (2020). *Developing the problem-solving skills for students in class 8 through instructing the first-degree equations in one unknown (Master's thesis)*. School of Education, Can Tho University, Can Tho City, Vietnam.
- Uyen, B. P., Tong, D. H., Loc, N. P., & Thanh, L. N. P. (2021). The effectiveness of applying realistic mathematics education approach in teaching statistics in grade 7 to students' mathematical skills. *Journal of Education and E-Learning Research*, 8(2), 185-197. Available at: <https://doi.org/10.20448/journal.509.2021.82.185.197>.
- Warshauer, H. K. (2015). Productive struggle in middle school mathematics classrooms. *Journal of Mathematics Teacher Education*, 18(4), 375-400.
- Yasin, M., Fakhri, J., Siswadi, Faelasofi, R., Saf'i, A., Supriadi, N., & Wekke, I. S. (2020). The effect of SSCS learning model on reflective thinking skills and problem-solving ability. *European Journal of Educational Research*, 9(2), 743-752. Available at: <https://doi.org/10.12973/eu-jer.9.2.743>.
- Yayuk, E., Purwanto, A. a., & Subanji, A. R. (2020). Primary school students' creative thinking skills in mathematics problem-solving. *European Journal of Educational Research*, 9(3), 1281-1295. Available at: <https://doi.org/10.12973/eu-jer.9.3.1281>.
- Yuberti, L. S., Anugrah, A., Saregar, A., Misbah, & Jermisittiparsert, K. (2019). Approaching problem-solving skills of momentum and impulse phenomena using context and problem-based learning. *European Journal of Educational Research*, 8(4), 1217-1227. Available at: <https://doi.org/10.12973/eu-jer.8.4.1217>.

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