Research Article https://doi.org/10.12973/ejmse.4.2.95

European Journal of Mathematics and Science Education
Volume 4, Issue 2, 95 - 109.
ISSN: 2694-2003
http://www.ejmse.com/

Problem-Solving Models Using Procedural Knowledge in Solving Mathematics Problems of Junior High School Students

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Received: December 3, 2022 ▪ Revised: March 27, 2023 ▪ Accepted: April 25, 2023

Abstract: The ability of students to build problem-solving models using procedural knowledge can be viewed from several aspects, including Mastery of Mathematical Problem Solving (MPS), understanding concepts and application of concepts, the relationship between learning outcomes of mathematics and interest in learning, and examine the contribution of the ability to understand concept problems, the application of concepts to the ability of MPS, as well as student difficulties and some of the advantages of students in solving problems. This experimental study aims to explain the effect of the MPS model using procedural knowledge on solving mathematical problems for Junior High School Students (JHSS). The findings showed that 1) The MPS method using procedural knowledge significantly improved learning outcomes, but the mastery of MPS for JHSS was still unsatisfactory. 2) MPS teaching could still not improve meaningful learning outcomes. However, when JHSS applied the concepts, calculations, and problem-solving aspects, MPS teaching improved meaningful learning outcomes. 3) Students' interest in learning mathematics in the two sample classes was classified as positive. Shortly, MPS teaching accustoms students to think systematically and creatively and not just give up on the problems they face.

Keywords: *Mathematics, model, problem solving, procedural knowledge.*

To cite this article: Syaiful, & Puspayanti. (2023). Problem-solving models using procedural knowledge in solving mathematics problems of junior high school students. *European Journal of Mathematics and Science Education*, *4*(2), 95-109. https://doi.org/10.12973/ejmse.4.1.95

Introduction

Model formation is one of the essential strategies scientists use to explain life problems, especially in mathematics and the natural sciences (Glubwila et al., 2021; Piñeiro et al., 2021; Rott et al., 2021). These models may be iconic or analogous, but they may also be theoretical or mental models for problem-solving (Heragu, 1992; Nurhayati et al., 2021). Various studies have shown that elementary school-aged children (Bacete et al., 2019; Syaiful et al., 2011) can build models to explain the observed symptoms (Kehayov, 2017).

It is recognized that humans are never free from various problems. The size of the problem depends on the activities carried out by humans themselves. The more activities they do, the more problems they cause. However, not all problems can be called problems. We encounter a problem daily, and no correct answer is immediately available (Glubwila et al., 2021; Piñeiro et al., 2021; Rott et al., 2021). For example, a student may face a problem they are unfamiliar with or do not yet have a specific algorithm to solve. It was said that the question caused problems for the student.

Solving a problem means finding a way to cross a gap that is unknown. If a gap is known about crossing it, it is called an exercise (Heragu, 1992; Nurhayati et al., 2021). To solve problems, students must first have several abilities, including the ability to understand concepts and problems (Glubwila et al., 2021; Nurhayati et al., 2021). Able to relate concepts to one another, apply concepts possessed in new situations, and evaluate tasks that have been done. In addition, problem-solving involves several types of increasingly complex learning (Bacete et al., 2019; Kehayov, 2017; Rofiqah et al., 2020; Syaiful et al., 2011), and problem-solving is a type of high-level learning (Balım et al., 2015). In other words, students who can solve problems are those who have high-level rule thinking.

In teaching mathematics, problem-solving is one of the objectives of the learning process (González-Castro et al., 2016;

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Gultepe et al., 2013; Pestel, 1993; Sumida & Mori, 2019). The importance of mathematical problem-solving skills for students was also revealed by the opinions of several experts, who, among other things, said that the problem-solving process (a) is an activity carried out by mathematicians in producing various theories (Jailani et al., 2020), (b) is everywhere, flexible, and whenever it can be used in mathematics, and other disciplines, 1990), and (c) has a close relationship with the method of discovery. Critical, creative, and independent thinking (Pestel, 1993) also reveals the importance of mathematical problem-solving skills for students because they are valid and have practical value. It makes students think about ideas and concepts and apply them, which helps them understand more about these ideas and concepts.

Our government, in this case, the Ministry of National Education, is well aware of the importance of problem-solving in the teaching of mathematics. In order to anticipate it, various efforts were made. One of which is directing the objectives of learning mathematics in junior high schools so that students can understand mathematical concepts and their interrelationships (Syaiful et al., 2020), develop reasoning power to solve problems encountered in everyday life (Clasen & Svoboda, 1975; Malaka, 1951; Nurhayati et al., 2021; Syaiful et al., 2019), develop mathematical problem-solving process skills to acquire mathematical concepts, and foster critical values and attitudes.

Solving problems in the form of mathematical problems is an aspect of teaching mathematics that contains many positive aspects (Bruner, 2020; Livingston et al., 2004; Meyer, 2010; Pintrich, 2000; Surya et al., 2013; Syaiful et al., 2020; Travers, 1982). Similar opinions were also expressed (Bandura, 1999; Zimmerman, 2002) in mathematics teaching, that problem solving can stimulate students' thinking and is oriented towards future challenges. Therefore, it is highly expected that every teacher familiarizes their students with the problem-solving process. Teachers should provide challenges for solving descriptive questions in the form of stories and applications to develop students' thinking power. However, the study results showed that students' lack of pleasure or interest in a lesson can reduce learning outcomes. Moreover, students' interest in mathematics has a positive effect on understanding mathematics (Havill, 2020; Sternberg, 2003). Then students' interest in mathematics and students' understanding of mathematics each positively influence learning achievement in mathematics. Several research results, such as finding a correlation of 0.67 between high school students' attitudes towards mathematics and their learning outcomes scores (Brandwein et al., 1959; Chi et al., 1988; Duncker, 1945; Havill, 2020; Mayer, 1992), so, some of these findings indicate that interest is needed to improve learning outcomes. Therefore, interest in learning needs to grow in students.

However, it is still found that the teacher's teaching method does not pay attention to student interests and does not utilize students' thinking abilities. Our teaching method makes students passive (Santos-Trigo, 2014; Szabo et al., 2020) In mathematics and physics, teachers love to give formulas. They range from simple to complex. These formulas must be memorized by students (Hmelo-Silver, 2004; Zulkarnain et al., 2021). Nowadays, the most commonly used method of teaching by junior high school teachers is the lecture method. Less challenging questions are given, and more questions that only manipulate symbols (routine questions) are given. As a result, students are less critical in their thinking (Santos-Trigo, 2014; Wong & Wong, 2019; Zulkarnain et al., 2021).

This study will compare two teaching methods in mathematics, conventional and problem-solving, using procedural knowledge. It is important to find alternative teaching methods to compare their effectiveness with the conventional method. In procedural knowledge, several steps can be used to solve problems in the form of problem-solving, namely generalization and discrimination, procedure and composition (Lin et al., 2017). Students who are taught the problem-solving method using procedural knowledge are actively involved. It means that each step of procedural knowledge is carried out by students themselves, whom researchers guide, while students who were taught conventional methods of solving problems in the form of problem-solving do not use the steps above. But in the usual way. Students are directly directed to work on the problem using memorized formulas without first analyzing the question's meaning.

Problem Formulation

Does the MPS method using procedural knowledge improve understanding of the application, problem-solving, and students' learning interests? The research questions were to be searched for. The details are:

1. Is there a significant difference in learning outcomes between students taught using mathematical Problem-solving methods using procedural knowledge and students taught using conventional methods, if viewed from the following aspects: 1) Concept understanding and problem understanding; 2) application of the concept; 3) problem-solving.

2. Is there an increase in learning interest, which means both students taught using MPS methods using procedural knowledge and students taught using conventional methods?

Methodology

Research Design

This research is an experimental study. The experimental design used was the pretest-posttest control group design. This design is described as follows:

A: 0 -------X------- 0

A: 0 ---------------- 0

Furthermore, the research procedures taken are: 1) They randomly divided the subjects into two groups: the experimental group subjected to the treatment variable and the control group not subjected to the treatment. 2) Give a pretest to the two groups, then determine the mean of each. 3) Trying to keep the conditions for both of them the same, except for the treatment in the experimental group. 4) Give a posttest to the two groups, then look for the mean of each. 5) Looking for differences between the results of the pretest and the results of the posttest for each group. 6) Compare these differences to see whether the difference was the result of the treatment given to the experimental group. 7) Using the correct statistics, is the difference significant or just a coincidence (Michelli, 2013).

This research was conducted in one of the public junior high schools in Jambi City, grade 7, semester 2. The sample subjects were derived from three equal classes. Randomly selected two classes from the three equal classes, and obtained classes VIIA and VIIC. From the two classes, the class that will be used as the experimental group and the control group are randomly selected. It turned out that class VIIC became the experimental class while class VIIA became the control group. Then, the experimental class was taught with mathematical problem-solving methods using procedural knowledge, while the control class was taught using conventional methods. This research involves three kinds of instruments: The mathematics problems-solving test (MPS), the interest in mathematics scale, and interviews about MPS implementation. These three kinds of instruments are used by students who have been selected as samples. Furthermore, the instrument was developed through several stages, namely: 1) the stage of making the instrument; 2) the instrument screening stage; and 3) the trial phase.

The MPS test is valid and reliable. It has content validity because it has been analyzed rationally. The benchmark for this rational analysis is not scores or other statistical measures but something that is qualitative in nature. Rational analysis is carried out by first making a grid. After that, a criterion test was carried out by three mathematics lecturers with doctoral degrees, and one mathematics teacher. When two of the four criterion examiners comment and agree, then the test is declared valid. It also fulfilled the criterion of reliablity because the results of reliability calculations using the alpha formula are equal to 0.617. Then, the test is ready to be experimented with.

Furthermore, interest in the mathematics scale was tested on students who were not the sample of this study to know the reliability of the scale. Furthermore, the data collected from the trial was processed using the Sprearman-Brown formula. This calculation produced a coefficient of $r = 0.82$. This indicated that the reliability of the interest scale is sufficient.

In addition, the scale of interest in mathematics comprises four aspects: (1) use of media to do activities of mathematics (investigation process), (2) feelings of pleasure or displeasure are associated with learning mathematics in the classroom, (3) the content of mathematics lessons, (4) read and talk about mathematics.

Interviews were structured using an adapted (structured) interview guide. The number of questions is 7 for the experimental class and 4 for the control class. This question is intended to clarify the data and information that have been collected through the final test.

Data Analysis

After the required data is collected, the next step is to analyze the data. To see the difference in the overall average score between the experimental class and the control class, the T test, F test, and Z test were carried out. Furthermore, for the qualitative data, the data analysis technique used has four stages: data collection, data reduction, data presentation, and the last step, drawing conclusions and verification. Data reduction is the process of simplifying, classifying, and removing unnecessary data in such a way that the data can produce meaningful information and facilitate drawing conclusions. This reduction stage is carried out to determine whether the data is relevant or not to the final goal. The presentation of data is an activity when a set of data is arranged in a systematic and easy-to-understand manner, thus providing the possibility of drawing conclusions. The last step is drawing conclusions and verifying them. This stage aims to find the meaning of the collected data by looking for relationships, similarities, or differences to be drawn. At last, to ensure the reliability of qualitative data analysis, the researchers achieved trustworthiness by making sure that the findings are dependable, credible, confirmable, and transferable.

Findings

Student MPS Learning Outcomes at the Beginning and End of the Treatment

Table 1. MPS Score on the Pretest and Posttest of the Experimental Class

Assessed Variables	Max. Score	Pretest N=37 $\bar{X}$	Pretest N=37 S	Posttest N=35 $\bar{X}$	Posttest N=35 SS	Gain
Concept understanding	20	7.49	2.38	8.81	1.26	1.32
Concepts application	30	3.92	1.15	15.40	6.1	11.48
Problem solving	50	4.11	1.18	26.57	6 ,75	22,46
Total	100	15,52	3,22	50,78	11,03	35,26

Table 1 shows that the average score of concept understanding at the beginning of the treatment was 7.49 (37.5% of the maximum score) and at the end of the treatment was 8.81 (44% of the maximum score). The average learning gain was 1.32 (17.6%) and the acquisition mean was 5%. The average calculated score of concept application was 3.92 (13%), while the average learning achievement was 22.46 (an increase of around 546.7%). Learning achievement was meaningful at 5%.

Table 2. MPS Score on the Pretest and Posttest of the Control Class.

Assessed Variables	Max. Score	Pretest N=37 $\bar{X}$	Pretest N=37 SS	Posttest N=35 $\bar{X}$	Posttest N=35 SS	Gain
Concept understanding	20	6.00	2.17	8.80	2.16	2.80
Concept application	30	5.14	1.07	9.68	2.29	4.54
Problem solving	50	4.03	1.18	17.81	5, 29	13.78
Total	100	15.17	3.33	36.29	6.77	21.12

Table 2 shows that the mean score of concept understanding at the beginning of the treatment was 6.00 (30% of the max score). At the end of the treatment, the average learning achievement was 2.80 (an increase of about 40.7%). The mean gain is 5%. The mean score of problem solving was 4.03 (8.1% of the maximum score) at the beginning and 17.81 (35.6%) at the end. Overall, both classes got significant learning gains, but the experimental class obtained a more significant portion of learning gains than the control class. This suggests that the problem-solving method using procedural knowledge is more effective in improving students' conceptual understanding, concept application, and problem-solving.

Table 3. MPS Score on the Final Test of Experimental Class and Control Class

Experiment Class n	Experiment Class $\bar{X}$	Experiment Class SS	Control Class n	Control Class $\bar{X}$	Control Class SS	different $\bar{X}$
35	50.78	11.03	35	36.29	6.77	14.49

Table 3 shows that higher scores (50.78) were obtained by experimental class students than control class students (36.29). Statistically, there is a significant difference (14.49). It means that the MPS method using procedural knowledge is more effective than the conventional method in increasing the students' learning outcomes.

Table 4. Summary of Results of Hypothesis Testing

Hypothesis	Analysis Counted	Analysis Table	Conclusion	Description
Concept understanding	t_c=1.95	t_t=2.04	Ho=received	∝ = 0.05
Concepts application	t_c=6.1	t_t=2.04	Ho=rejected	∝ = 0.05
Problem solving	t_c=6.7	t_t=2.04	Ho=rejected	∝ = 0.05
Experiment Class	Z=2.6	Z>1.96	Ho=rejected	∝ = 0.05
Control Class	Z=1.7	Z<1.96	Ho=received	∝ = 0.05
**	t_c=6.6	t_t=2.04	Ho=rejected	∝ = 0.05

Note: ** is the difference in the average score of overall MPS learning outcomes in the two sample classes.

Based on the data stated in Table 4, it can be summarized that the MPS method using procedural knowledge was not effective in improving the concept understanding of students, but it was effective to improve the concept application and problem solving. Overall, the MPS method using procedural knowledge was more effective in improving the students' learning outcomes than the conventional method.

Table 5. Classification of MPS Scores of Students in Experimental Class

Score of	Number of Subjects		Percentage	
	Pretest	Posttest	Pretest	Posttest
Bad	7	4	18,90%	11,40%
Fair	27	24	73%	68,60%
Good	3	7	8%	20%
Total	37	35	100%	100%

Based on table 5, in the experimental class, there is a decrease in the percentage of 18.9% to 11.4% (7.5%) students who get fewer marks and an increase in the percentage of 81% to 88.6% (7.65) students who get enough or good scores.

Table 6. Classification of MPS Score Students in the Control Class

Score of	Number of Subjects		Percentage	
	Pretest	Posttest	Pretest	Posttest
Bad	5	8	14,30%	21,60%
Fair	27	23	77%	62%
Good	3	6	8,50%	16,30%
Total	35	37	100%	100%

Table 6 shows that in the control class, there was an increase in the percentage of 14.3% to 21.6% (7.3%) of students who scored less and a decrease in the percentage of 85.5% to 78% (7.5%) of students who get a good or enough score.

Students' Interest in Learning Mathematics at the Beginning and End of the Treatment.

The interest in mathematics scale comprises four aspects: mathematical tools to do mathematical activities (investigation process). Feelings of pleasure or displeasure are associated with learning mathematics in the classroom. The score of the measurement of the student's interest in mathematics in the experimental group at the beginning and end of the treatment, and the score for the measurement of the student's interest in mathematics in the control group at the beginning and end of the treatment are listed in Table 7.

Table 7. Average Score of Interest Scale Measurement at the Beginning and End of Treatment

Class	Initial Score		Final Score		Description
Neutral Score	40		40		
N	$\bar{X}$	SS	$\bar{X}$	SS	
VII A (n=32)	49.13	8.84	52.43	7.73	Control Class
VII C (n=33)	49.37	8.52	54.95	6.76	Experiment Class

Table 7 shows that the average score of the interest measurement of the experimental group students and the control group students at the beginning and end of the treatment tended to be positive. The control class group had an average increase in interest of 3.3 (difference between posttest and pretest). Calculations using the Z test showed that the increase in interest was not significant (Z_{hit} = 1.74) and Z (table) = -1.58. However, when tested by t-test, there was no significant difference. This suggests that solving mathematical problems using procedural knowledge can increase students' interest in learning mathematics.

Interviews' Data

After interviewing the participants with several questions related to the students' interests and the use of MPS steps using procedural knowledge, the researcher obtained the following data:

About students' interests

1. "Do you like studying or solving questions like in the previous exam?" Asked the researcher. This question aims to see whether students are interested or not in solving math problems. The assumption underlying this question is that someone who is interested in doing something will try their best. It turned out that their answers were somewhat the same, that is, they liked it even though the question was rather difficult, and only one person answered that they didn't like it.

Furthermore, the researcher asked the following questions, namely to each student who liked. Then the researcher asked, "Why?" Students answered, "It is very useful for me to increase my knowledge of solving math problems." (These answers are summarized from 6 students.) "For arithmetic exercises (summarized from 2 students)". "To be able to solve questions on other subjects (A student answered)" "Because my way of thinking is organized to answer questions on the national evaluation" (summarized from two students). To those who answered He didn't like it, the researcher asked, "Why?" He answered because it was too difficult. Then the researcher asked again, "Which question?" "Questions parts B and C" (concept application and problem-solving).

2. "Have you ever studied questions like that?" The purpose of this question is to find out whether the teacher has previously given questions in the form of problem-solving. (as in part c). It turned out that the students' answers varied. that is:

"Once, but not as confused as this problem" (answered two students). "Never, there are only ordinary questions (answered by 7 students)". "Yes, but the solution is not using the method you taught" (three students answered). The researcher's impression was that, so far, the teacher rarely gave problem-solving questions.

3. "Of the five questions in Part C, it turns out that question No. 13 you answered completely. Why?" asked the researcher. Two students answered. "Because my father often asked me to pay the electricity bill." "The problem is rather easy; besides, I like to solve it because it is found in paying electricity bills. (These answers are summarized from ten students.) The researcher gets the impression, that students are very interested in solving math problems if the problem is useful for their daily lives.

Then the answers related to the interest in learning mathematics from the control class were analyzed.

1. "Do you like studying or solving problems like in the exam yesterday?" This question aims to see whether students are interested or not in solving math problems. The assumption underlying this question is that someone who is interested in doing something will try their best. It turned out that the answers from the control class students were beyond the researchers' expectations, because all of them answered "like it, but it's difficult". Then the researcher asked another question. "Why?" "Because with questions like this, it's easier for me to learn and try to answer them with my friends." (Answers are summarized from two students). "Because these questions are often found in everyday lives, it is easier to understand them" (summarized from the answers of two students). "Because questions like this make it easy to remember symbols, formulas, and units, then our way of thinking expands." (Answers are summarized from two students). " Because having questions like this makes it easier for us to learn other questions (summarized from two students). "Because later on who knows it will come out in the national exam, and we can already answer it. (A student answers.) "Because of questions like this, we think a lot and don't guess. (summarized from three students).
2. "You said earlier that you like to do difficult questions, but after you checked, why were your answers wrong? Asked the researcher (answers to questions in parts B and C.) To this question, students answered, among other things: "I have never faced a problem like this, even though you have explained it, I still don't understand" (this answer is summarized from the front of the students). "In the past, I was given student worksheets by the teacher to make questions, but questions like this left me confused (answered a student).
3. "In Part C, you see that many questions have not been answered; you only write down what is known and what is asked; after that, it is blank. Why?" The purpose of this question is to find out what difficulties students face when solving math problems. To this question, they answered, "Don't know which formula to use" (summarized from the answers of three students). "The problem is convoluted, so I don't know which one to do first" (Summarized from the answers of four students). "I don't know how to make the picture" (summarized from the answers of two students). "I'm not good at arithmetic, to answer fraction questions" (summarized from the answers of three students). Researchers get the impression that when facing questions in the form of problem-solving, students often experience difficulties, as the researcher summarizes from the answers above.
4. "How can you be able to solve a question like this?" The purpose of this question is to reveal the contents of students' thoughts, whether they also want to be taught steps in solving mathematical problems. Student answers to this question are: "Study hard and be good at managing time" (summarized from two students). "By memorizing which formulas to use" (summarized from four students). "The trick is that we have to remember symbols, formulas, and ways to solve problems" (answer of a student). "You have to be good at counting with fractions" (summarized from four students). "The method is that every time the teacher explains, we listen and pay attention, when asked to do homework, we do it: and we often discuss the questions with friends who can do the task well" (a student answered). From the students' answers, the researcher obtained the impression that there was no tendency for students to want to be taught using MPS methods. It is assumed that maybe they don't know that there are several steps to being able to solve the problem.

About Using Steps to Solve Mathematical Problems with Procedural Knowledge

The following questions are questions for the experimental class:

1. "Have you ever used the steps like what you taught before?" This question aims to find out how students solve

problems before the researcher introduces the steps for solving mathematical problems to them. To this question, they all answered, "There are ways to use it, but not as the researchers teach". Then the researcher asked again, "How?" To this question, their answers are the same. "The method is like writing down what is known, what is being asked, and then answering" (answers of twelve students). "Is that the way the teacher taught?" said the researcher. "Yes, but in math books there is also", said the students. Researchers get the impression that, so far students have only used simple steps in answering questions. If these steps are used to solve problems in the form of solving mathematical problems in general, students who are classified as medium (moderate) or below are less successful because they do not analyze the problem first.

2. "Did you use all the problem-solving steps in answering the questions on the exam yesterday?" The assumption underlying this question is that if students really receive what is given, then whenever needed, they will definitely use it. To this question they all answered that they had used it.

3. "You said you had used all the steps in answering the questions, but after you checked, the answers were incomplete and something was wrong. Why?" This question is to see if students face obstacles in using all of these problem-solving steps. It turned out that, based on the answers of students in general, they still faced obstacles. Answers from students are presented as follows: "Because the time is very short." Answered a student. "Because I can't determine the formula according to what was asked," answered two students. "Because of the seventh, eighth, and ninth steps, I can't," said five students. "Because I don't know what concept to look for first," said a student. "Because I don't understand how to make pictures," said two students. "Because the steps to find the answer are often reversed," answered a student. Researchers get the impression that students are interested in using steps to help solve problems, but on the other hand, they still have problems. The reason is that this strategy is still new and they are not used to using it.

4. "What do you think about the problem-solving steps that you teach?" In general, students answered that it was useful for them. Then the researcher asked again, "Where is it used?" "It can help us solve difficult problems," said four students. "It can lead, but sometimes it can be confusing too." Answered two students. "Sometimes the questions are difficult to understand too, but when you understand them, you can direct them," said two students. "Useful for me because this step trains me to count a lot," said four students.

Discussion

Students' Understanding and Student Learning Outcomes in MPS

Based on data analysis and hypothesis testing, there is a significant difference between the average of MPS scores obtained by the experimental class students and the MPS average scores from the control class. In this case, the average score of the experimental class is higher than the average score obtained by the control class students, and this result is strengthened by the results of previous studies (Dunlosky et al., 2013; Germann, 1988; Russo et al., 2020). It means that the method of MPS using procedural knowledge steps is more effective than conventional methods to improve students' mathematics learning outcomes in junior high school. However, if viewed from various perspectives namely aspects of conceptual understanding and problem understanding, application of concepts and aspects of problem-solving, students' understanding of MPS and MPS learning outcomes achieved in the two sample classes showed unsatisfactory average scores of learning outcomes. This fact is illustrated by the results of the average score obtained by the experimental class students on the final test, which is 50.78 with a standard deviation of 11.03, and the average score obtained by the control class students is 36.29 with a standard deviation of 9.78, indicating that the distribution is not evenly distributed/spread out the scores obtained by students, especially students in the experimental class.

In Table 5, it can be seen that only about 20% of the experimental class students scored quite well, and 80% of the other students were classified as sufficient or less. In general, about 80% of students have not been able to solve mathematical problems well. Their understanding of solving mathematical problems has not been good because they find it difficult. After all, they are new and are not accustomed to using the given solving steps. This result is reinforced by the findings of several other researchers (Pintrich, 2000; Syaiful et al., 2011). According to the interviews, although they like to solve problems in the form of MPS, they still experience difficulties, among others, in making supporting pictures, determining the right formula for the concept that needs to be searched first, and manipulating the concept formulas. If this condition can be resolved, of course, the results will be different. This statement is supported by a theory put forward (Hayes & Kraemer, 2017; Nurhayati et al., 2021; Riyanto et al., 2019). The theory stated that the method or steps of solving mathematical problems aim to train thinking processes as well as mechanical processes and help students complete complex exercises. Furthermore, the MPS methods can help students, especially in sorting and systematically analyzing data (Rott, 2021; Sezgin Selçuk et al., 2008).

Overall, in both the experimental and control classes, the results showed that MPS learning outcomes ranged from 36% - 51 % of the total score. This result follows the finding of a previous study (Priemer et al., 2020), which states that the answers of high school students to math problem-solving problems are never 100% correct. Similarly, the findings (Dunlosky et al., 2013; Lin et al., 2017) found that the average math problem-solving skill of first-year students is 56.3

or only about 56% of the total score. So, the score of problem-solving learning outcomes obtained by JHS students is not sufficient. However, the two methods tried resulted in a significant increase in learning outcomes scores (difference between the posttest and the pretest) both from the aspect of concept understanding and problem understanding, concept application, and from the aspect of solving mathematical problems; these results are in line with the findings (Darling-Hammond et al., 2020; Lauritzen, 2012). Overall, the improvement achieved by the experimental class students was better than that achieved by the control class students. These results will positively impact the use of MPS methods with procedural knowledge to improve mathematics learning outcomes for JHSS.

Although the average learning achievement of the experimental class is more remarkable than that of the control class, statistically significant differences only occur in aspects of concept application and Problem-solving. In contrast, in aspects of conceptual understanding and problem understanding, there are no significant differences. It shows that understanding mathematical concepts and mathematical problems between the experimental and control classes is the same. These results are not much different from the results of other studies (Phonapichat et al., 2014). This finding is indeed somewhat different from the opinion of the mathematics teachers in studies (Abramovich et al., 2019; Syaiful, 2013), and a theory (Gagné & Gagné, 1985). The ability to solve mathematical problems can improve the ability to understand concepts. This difference can be considered reasonable because (1) In this study, the treatment of concept understanding (explanation of the theory) was not distinguished between the experimental and control classes. However, the different treatment is when solving problems in the form of problem-solving. (2) The use of MPS steps in the experimental class was new to the JHSS where this research was conducted, and they were interested. Rationally, if something new is introduced and students feel interested, they continue to use it mainly to answer questions (aspects of applying concepts and problem solving), so more time is taken up. Then the remaining time is used to answer questions about understanding concepts and understanding problems.

As stated by a theorist (Bandura, 2009), understanding a person's concept has a different level of meaning according to their ability. Furthermore, Skemp (1978) distinguishes two types of conceptual understanding: instrumental understanding and relational understanding (Federal & Internacional, 2012; Skemp, 1978). Instrumental understanding is defined as understanding separate concepts and only memorizing formulas for simple calculations. The relational understanding contains a schema or structure that can be used to solve broader problems. According to Binet's functional theory of intelligence, the more intelligent a person is, the more capable they are of making their own goals and taking initiative without being directed by others (Schleicher, 2018). It means that his intrinsic motivation is good enough. He will adapt the methods used to achieve the goals to the conditions and situations he faces. From some of the explanations that have been put forward, it turns out that they reasonably support the assumption above that internal factors (input quality) can affect the level of conceptual understanding.

The experimental group had better achievement in applying mathematical concepts and problem-solving than the other class. This is due to the fact that students are involved in calculations when solving problems. If the calculation is done without direction, students feel confused and get bored, while if it is done with problem solving steps, students are more focused and become more skilled in counting. This statement is supported by the theory put forward by Pestel (1993) that the purpose of a model or steps in solving math and science problems is to enable students to work more actively, and students will acquire skills for themselves. When viewed from the percentage (tables 8, 9, and 10) of students who obtained a satisfactory or good MPS score, it turns out that the experimental class obtained an adequate increase in the graph (81%-88.6%), while the control class happened the other way around (85.5 %-78.3%). According to the interviews with these students after the final test, the results were obtained by the control class students (a decrease of 7.2%). In answering the MPS questions (especially part c), they feel they do not know which one to do first, what formula is suitable to use, how to draw it, or how to count. There is indeed a match if the student's opinion is related to the theory put forward (Carson, 2007; Mettes et al., 1981; Schleicher, 2018). Mettes et al. (1981) stated that students seemed confused when faced with mathematical problems because they did not know where to start. Meanwhile, Skemp (1978) reported that students who did not use problem-solving steps ran away with problems and quickly relapsed into trial-and-error thinking.

In addition, if the average MPS score achieved by students from the two classes is associated with the score of previous student learning outcomes, namely the mathematics summative score of students, the test conducted by the teacher at the end of the fourth semester (grade promotion exam, data is attached), as shown in Table 8, it appears that there is a relationship between the average MPS score and the average score of the summative mathematics test. In a class with a high summative test score, the MPS score is also high. It means that the prerequisite ability factor (previous learning outcomes) will support the results achieved in the MPS.

Table 8. Average Score of MPS on Final Test and Average Score of Mathematics Summative Test

Class	MPS Score	Summative Score	Description
VII A	36.29 9.78	57.9 5.2	Control class
VII C	50.78 11.03	59.2 5.1	Experiment class

Table 8 shows that the MPS questions prepared by researchers for JHSS are more complex than the summative test questions made by the teacher. This is supported by interviews with students, who stated that the questions were too complex and had never been studied. Perhaps questions like MPS can be digested by those who learn in private or less or by those who are competent.

Students' Interest in Mathematics

This study found that both at the beginning and end of the treatment, the experimental and control class students' interest in mathematics led to favorable results. Viewed at the beginning and end of the treatment, it appears that there is an increase in the degree of positivity of students' interest in mathematics. However, statistically, the increase in the degree of positivity of interest in control class students is not significant ($Z = 1.74$) and Z_{tab} ($-19.6 < Z < 1.96$). While the increase in the degree of positivity of interest in experimental students is significant at the 5% level ($Z = 2.6$), this means that problem-solving methods using procedural knowledge steps can increase students' interest in mathematics at the 95% confidence level.

This finding follows the previous relevant findings carried out by Ajewole (1991). He recommended that teaching mathematics using the discovery (problem-solving) method allows students to clearly show a favorable attitude towards problem recognition and mathematical problem solving compared to learning with the expository method. Ajewole (1991) conducted the research on 240 high school students from 6 schools in Oyo State, Nigeria. The experimental group showed a more favorable attitude toward mathematics than the control group ($t = 8.87$, $p < 0.01$). Several research results using interest and attitude as independent variables show that interest and attitude significantly positively correlate with various human achievements and abilities. At the same time, Germann (1988) found that interest and achievement in learning calculus in physics majors have a high correlation (0.895). Next, German found a correlation of 0.67 between high school students' attitudes towards mathematics and their learning outcomes scores (Germann, 1988). If the above findings are related to the findings in this study, it can be seen that there is a relationship between student learning outcomes on the MPS test and the results of students' improvement in the interest scale measurement.

Table 9. MPS Average Score and Interest Scale on the final Test

Class	MPS Score		Interest Score		Description
N	$\bar{X}$	SS	$\bar{X}$	SS	
VII A (n=32)	49.13	8.84	52.43	7.73	Experiment Class
VII C (n=33)	49.37	8.52	54.95	6.76	Control Class

Based on table 9, the higher the degree of positive interest in learning, the higher the average score on the MPS. If the assumption is analyzed statistically using the Gamma formula (to find the association relationship between the interest scale score and the MPS score), the method is shown in Table 10 below. The results of calculations with the gamma formula are:

Gamma = $\frac{F_a - F_i}{F_a - F_i}$ obtained Gamma value = 0.674 These results show that these allegations are justified by 67%.

Table 10. Relationship between Interest Scale Score and MPS Score

Interest Scale Score	MPS Score: Poor	Fair	Good	Total
Poor	5	16	0	21
Fair	15	60	10	85
Good	0	23	15	38
Total	20	99	25	144

Therefore, interest can be said to be one of the predictors of a person's learning success. If the experimental class and the control class are also compared, the average score of the interest scale measurement at the end of the treatment shows no significant difference ($t = 1.65$ and t_{tab} $-1.96 < t < 1.96$). It is probably due to students' opinions from both the control and experimental classes towards solving mathematical problems in the same direction. The interviews with students from both classes showed that they were happy to solve MPS questions, even though the results were not optimal. Experimental class students feel that MPS can increase knowledge in everyday life and answer questions in the National Examination (UN). This opinion is based on the findings (Basham, 2012; Szabo et al., 2020) that students generally prefer to solve mathematical problems related to everyday life. Control class students felt that MPS studied many problems related to everyday life so that it was easier to understand them.

Their enjoyment of MPS is also seen in their opinion about the usefulness of solving MPS questions. Experimental class students think that MPS questions are helpful because they solve complex questions and can practice counting. Control class students think that MPS questions are helpful because they make us think a lot and not guess. It turns out that if their opinion is related to the theories of several experts regarding the importance of mathematical problem-solving skills for students, there is a match. Previous studies (Klerlein & Hervey, n.d.; Schoenfeld, 2016; Tuma & Reif, 1980) stated that solving mathematical problems was important because problem-solving is everywhere. It can be used at any time, both in mathematics and in other disciplines. Furthermore, previous studies (Sharma & Ali, 2018) also mentioned that problem-solving had a close relationship with the discovery of critical, creative, and independent thinking.

Teaching MPS by Using Procedural Knowledge

Some Student Difficulties

As stated in the previous section, this relatively short research project (only one subject) has not produced satisfactory results, even though success phenomena have been seen. Students still experience some difficulties in using procedural knowledge steps to answer questions in the form of problem-solving. From the results of observations during the treatment, the difficulties that dominated were in terms of:

1). Calculations, especially in solving fractions

For example: * $1/4 + 1/5 + 1/6 = \ldots$

2). Designing additional drawings

3). Determine what concepts to look for first and the right formula to solve them.

The difficulties experienced by students in using the MPS step follow the difficulties experienced by students in the findings of previous experts, namely in identifying questions to make additional images, determining suitable formulas, and applying mathematical concepts or rules (Adkins, 1964; Meier et al., 2021; Mettes et al., 1981; Monahan, 2021). In the following table 14, these students' difficulties in solving problems in problem-solving (part C questions) can be seen more clearly.

Table 11. Students' answers to each item in parts A, B, and C

Problem Part A and B	**Experiment Class**																			
	Answers																			
	A						**B**		**C**					**D**			**Percentage (%)**			
No.	**T**			**F**	**T**		**F**		**T**		**F**		**T**		**F**		**T**		**F**	
1	27			8	13		22		-		-		-		-		57		43	
2	14			21	20		15		-		-		-		-		49		51	
3	16			19	12		23		-		-		-		-		40		60	
4	20			15	16		19		10		25		22		13		49		51	
5	10			25	7		28		-		-		-		-		24		76	
6	34			1	33		2		29		6		-		-		91		9	
7	27			8	17		18		15		20		-		-		56		44	
8	20			15	6		29		3		32		-		-		28		72	
9	18			17	13		22		9		26		-		-		38		62	
10	26			9	16		19		12		23		-		-		51		49	
	Average score (%)																48		52	
Part C	**Steps**																			
No.	**1**			**2**	**3**		**4**		**5**		**6**		**7**		**8**		**9**		**%**	
	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F
11	32	3	32	3	20	15	31	4	28	7	27	8	20	15	16	19	15	20	70	30
12	34	1	34	1	-	-	33	2	31	4	28	7	21	14	17	18	17	18	77	23
13	32	3	32	3	18	17	31	4	28	7	27	8	16	19	13	22	12	23	66	34
14	25	10	25	10	8	27	21	14	13	22	4	31	2	33	0	35	0	35	31	69
15	20	15	18	17	11	24	15	20	10	25	6	29	3	32	0	35	0	35	26	74
Average(%)	81			80	40		75		59		52		36		26		25		52	48

Table 11 showed that in the third, fifth, eighth, and ninth steps, students have difficulties. In the 3rd step, an average of 40% of students can make additional drawings; in the 5th step, an average of 24% of students can determine the right formula for the concept that needs to be searched first; in the 8th step, an average of 28% of students can perform calculations; and in the 9th step, only 38% of students were able to find the correct answer.

To overcome the difficulties faced by students in both the experimental class and the control class, the researcher tried to reduce them by:

1). Assign students to abstract all the formulas related to the subject being studied.

2). Consulted with several related teachers, especially seventh, eighth, ninth-grade mathematics teachers.

3). Extra work, meaning in terms of calculations, for example, taking over a temporary math teacher

Completion of MPS Questions by Students

After completing the treatment, which lasted about ten weeks, the students from the two sample classes carried out the final test. Tables 11 above and 12 below compare the correct and incorrect answers for each final test item. In Table 11 (experimental class), it can be seen that the average percentage of incorrect answers is 52%. One of the causes of this result is suspected to be a conceptual error (written measuring, supposed to count) in item no. 1 (b), so that students are confused in determining the answer (only 13 students out of 35 answered correctly).

Table 12. Student Answers on Each Item Part A, B, and C

Problem Part A and B	**Control Class**									
	Answers									
	A		**B**		**C**		**D**		**Percentage (%)**	
No.	**T**	**F**	**T**	**F**	**T**	**F**	**T**	**F**	**T**	**F**
1	26	11	14	23	-	-	-	-	54	46
2	12	25	22	15	-	-	-	-	45	55
3	15	22	15	22	-	-	-	-	41	59
4	18	19	16	21	8	29	22	15	43	57
5	8	29	7	30	-	-	-	-	20	80
6	27	10	25	12	23	14	-	-	68	32
7	20	17	10	27	8	29	-	-	34	66
8	5	32	2	35	1	36	-	-	7	93
9	10	27	7	30	3	34	-	-	18	82
10	19	18	10	27	6	31	-	-	32	68
	Average score (%)								37	63
Part C	**Steps**									
No.	**Known**		**Asked**		**Answer**			**Description**		
	True	False	True	False	True	NC/NT	False			
11	25	12	25	12	-	18	19	NC stands for all answers correct but not complete		
12	33	4	30	7	3	20	14			
13	27	10	25	12	1	13	23	NT stands for all answers not true, but complete		
14	17	20	12	25	-	8	29			
15	12	25	11	27	-	4	33			
					2.2%	34%	64%			

In table 12, the average percentage of students' correct answers to questions in parts A or B is 37%, and the wrong answers are 63%. The results achieved by the control class students are also inseparable from conceptual errors, as stated above. Meanwhile, for Part C questions (using the usual steps), only four students, or 2.2%, were able to answer correctly, 34% answered partially correctly, and 64% answered incorrectly. It means that steps such as what is known, what is asked, and what is immediately answered, for students classified as moderate, are less successful in answering questions in the form of problem-solving. Similar results were also reported by other researchers (Dunlosky et al., 2013; Silver & Cai, 1996).

Furthermore, in Part A, Number 2 a, the answer key used to check the students' work reads "to give a small value." None of the students answered like that. However, the student's answer is "to be able to give great marks." " It turned out that after being re-examined, the student's answer was correct and the answer key was wrong. In this case, the researcher has re-examined the students' work, as presented in tables 11 and 12.

Conclusion

Teaching mathematical problems using procedural knowledge can improve learning outcomes, but the mastery of MPS for JHSS is still not satisfactory. The percentage of students who achieved a satisfactory or good score on the pretest and final test was 81% and 88.6%, respectively. Additionally, students' interest in learning mathematics was positive in both experimental and control classes, but the difference in the increase in student interest in learning between the two classes was not significant. In a class with a higher degree of positivity, the higher the MPS learning outcomes. Students' interest in learning and previous learning abilities support the improvement of MPS learning outcomes, but implementation of MPS teaching with procedural knowledge takes a long time, and students still have difficulty answering MPS questions.

However, students felt happy working on MPS questions, and the experimental class found that teaching MPS could help solve complex questions, answer questions on the National Examination, and practice arithmetic. This study has several advantages and weaknesses, such as one sub-item that turns out to be the wrong concept.

Recommendations

This study supports the rationale that teaching MPS using procedural knowledge is an alternative teaching method that can improve students' mathematics learning outcomes. It provides recommendations such as more harmonious cooperation between fellow teachers, a thought-provoking teaching plan, and an understanding of concepts, problems, and count. The MPS process is still a problematic aspect for JHSS, but it is suspected that many other aspects are also related to MPS learning outcomes. Further research is needed to add these two factors.

Limitation

Limited time and cost caused this research not to examine further about other internal and external factors related to learning outcomes of MPS.

Acknowledgements

The authors appreciate the participation, effort, and support of students involved in this study. Many thanks to the teachers as well.

Funding

No funding supports this article.

Authorship Contribution Statement

Syaiful: Concept and design, data acquisition, data analysis / interpretation, drafting manuscript, securing funding and final approval. Puspayanti: Editing/reviewing, admin, technical or material support, supervision, critical revision of manuscript and final approval.

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