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# Students' Ability to Solve Story Problems on Systems of Linear Equations Using John Dewey's Approach

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**Abstract:** Students can study everyday mathematics with a story problem. Through this problem, students gain critical thinking experience in solving problems. The ability of students to solve problems through John Dewey's approach is also seen to deepen students' mathematical concepts in three-variable linear equation systems. Problem solving with John Dewey's approach consists of five stages. This method of research uses a qualitative descriptive approach with three persons as the subject of the research, with good, sufficient, and less as the categories of ability. The results of the research showed the subject's ability to solve a story problem with the John Dewey approach. Four given questions showed that the subject with a category of good ability can solve two problems with clear mathematical concepts. Whereas the student with sufficient ability can only solve one problem with an obvious mathematical concept. However, the subject with less ability is only able to solve a problem until the stage of inventorying several solutions, which is the third stage of problem solving with the approach of John Dewey.

**Keyword:** problem solving, story problem

## INTRODUCTION

Problem-solving strategies are still a challenge in learning mathematics. Proper problem selection and good problem explanation can direct students to observe the available data, represent the problem mathematically and choose the right method in solving the problem. Mathematical problem-solving constitutes an important area of mathematics instruction (Klang et al., 2021, p. 1). The main challenge for educators is to ensure that problem solving can deepen the conceptual understanding of the mathematical material studied. Problems-solving instruction creates opportunities for students to apply their knowledge of mathematical concepts, and integrate and connect isolated pieces of mathematical knowledge (Klang et al., 2021, p. 2).

In this context, John Dewey's educational theory offers a relevant approach. Dewey's educational philosophy, known as "learning by doing", emphasizes the importance of hands-on experience in the learning process. This approach provides an alternative to how mathematics should be taught to students with a variety of learning interests, linking math with everyday activities and then moving towards more abstract knowledge. Abstract thinking is essential to solving problems mathematically. According to (Österman & Bråting, 2019, p. 465) In order to solve mathematical problems successfully you need the reasoning ability, context-sensitivity and situational understanding as well as a ability to perform the calculations needed.

Some research findings show that problem-solving learning gives students the opportunity to apply knowledge of mathematical concepts, as well as integrate and connect separate parts of the mathematics knowledge. Proper representations, such as diagrams, graphs and drawings, can also help students in cognitive tasks, both in reasoning and problem solving (Marsigit et al., 2020, p. 318). The steps developed by John Dewey in solving problems are: (1) confront problem, (2) diagnose or define problem, (3) inventory several solutions, (4) conjecture consequences of solution, (5) test consequences (Carson, 2007, p. 8). These phases will operatively strengthen the mathematical concepts taught.

Problem solving or problem solving can be presented in a story (Rahmawati & Permata, 2018, p. 173) in particular involving a linear equation system of three variables, selected to provide relevant challenges to students. Student problem-solving skills can also be developed using material that can be associated with everyday problems. (Sari & Lestari, 2020, p. 287; Unonongo et al., 2021, p. 44). The purpose of this story is to cultivate problem-solving skills and strengthen mathematical concepts. The problems given in the form of stories also stimulate students in identifying issues, and solving problems mathematically (Fauziah & Astutik, 2022, p. 997) through the representation of mathematical concepts in everyday life.

However, most students still have trouble finishing a story-related philosophy. (Tello, 2010, p. 16). Early observations revealed that students still need a lot of instruction and guidance in their mathematical and narrative work. When students are given a new problem, unlike the previous one, they are less able to solve it, especially if only guided by books and also examples presented in books. Besides, the students' ability in the concepts of mathematical operations is still very low, making the results of the calculations of the given subject less accurate.

Similar research, against problem solving strategies in mathematical learning directing students to read about stories then students solve problems on three variable linear equation systems, has been shown earlier. However, the explanation of mathematics concepts reinforced through problem-solving is important to do. Especially for students with heterogeneous abilities. This study aims to describe the problem-solving ability of students through measures developed by John Dewey. This approach is expected to strengthen the mathematical concepts on three-variable linear equation systems.

## METHOD

This research was held at Hasanuddin's MA in the 2021/2022 full-term academic year. The approach to this research is qualitative research. This type of research is descriptive research. On this study will describe the ability of students in solving the problem of matter linear equation system of three variables based on John Dewey's problem solving steps. The instruments used in this study are a written test of four subjects, interviews and validation of the written test guidelines and interviews. Subjects in this study are students X class IPS MA Hasanuddin who totaled 11 students were given questions in the form of stories about the tested material, then took samples of as many as 3 students with the ability to solve different problems. All the tests and interviews tested have been validated in advance. Indicators on the test can be seen in Table 1.

**Table 1.** Indicators of Problem Solving Ability by John Dewey Steps

Problem Solving Steps by John Dewey	Reproduction of Mathematical Concept Understanding	Score
<i>Confront Problem</i>	Recognize the question presented is a question of the linear equation system of three variables and recognize the difficulty of the question	4
	Recognize the question presented is a question of the linear equation system of three variables and recognize the difficulty of the question, but the answer given is inaccurate	3
	Recognize the question presented is a question of three variable linear equation system only but does not recognize the difficulty of the question or recognize difficulty the question, yet does not acknowledge the question is a matter of the linear system of equation three variables	2

Problem Solving Steps by John Dewey	Reproduction of Mathematical Concept Understanding	Score
	Do not recognize the question presented is a question of the linear equation system of three variables and does not know the difficulty of the question	1
<i>Define Problem</i>	Writing what is known and what is asked by the subject exactly	4
	Menuliskan apa yang diketahui maupun yang ditanyakan oleh soal namun jawaban yang dituliskan tidak tepat	3
	Writing what is known or what is asked by the question, but the answer is written incorrectly	2
	Don't write down what is known or what is asked.	1
<i>Inventory Several Solutions</i>	Use the understanding that you have to know that the subject presented is a subject that has been encountered or almost identical to the one that has already been found.	3
	Using the understanding they have to understand the subject, but the student is still confused whether the subject presented is a subject that has been encountered before or almost the same as the one that has already been found.	2
	Not having an understanding so that not knowing what is presented is a matter that has been met or similar to what has ever been known	1
<i>Conjecture Consequence of Solutions</i>	Applying the problem solving procedure of the three-variable linear equation system accurately and correctly	4
	Implement a three-variable linear equation system troubleshooting procedure by writing only partial answers and most answers correctly	3
	Applying three-variable linear equation system troubleshooting procedures by writing the answer but wrong or writing a small part of the answer correctly	2
	Do not apply the problem solving procedures of the three-variable linear equation system at all or apply the problems solving procedure of the system of three variable lineary equations but are all incorrect	1
<i>Test Consequences</i>	Using the hypothesis obtained and determining the conclusion from the question correctly	3
	Using the hypothesis obtained and determining the conclusion from the question but wrong	2
	Do not use the hypothesis obtained and determine the conclusion from the issue	1

Data analysis techniques refer to Miles and Hubermna (Sugiyono, 2018) with stages (1) data collection, carried out by performing written tests on students. (2) Data reduction, researchers select three students to be subjected to research that represents good, sufficient, and less skills, (3) Data presentation, by Compiling a brief outline of the third student's work reviewed from John Dewey's problem-solving steps. (4) Verification is done from the results of mathematical concepts reinforced at each step of problem solving.

The validity of the data in this study was done with triangulation technique. The researchers collected different data from the same subjects. In addition to collecting data by conducting a written test, interviews were also conducted. This triangulation is intended to obtain a comparison of the results obtained from the problem-solving skill test, as well as the data obtaining from an in-depth excavation of information by conducting unstructured interviews with students after the test.

## RESULT AND DISCUSSION

The results of the data collection phase are obtained from observations, validation results, test performance results and interview results. The results of the test by 11 students obtained a list of values which the researchers then analyzed the problem-solving ability category that they possessed into 3 categories, namely good problem solving ability, sufficient problem-resolving ability and less problem-solution ability. From these results the researcher then re-focused the subject of the research into 3 students randomly selected from the three categories that have already been mentioned. Three such research subjects included 1 student with good problem- resolving category, 1 students with sufficient problems-resolution ability and 1 Student with less problem resolving skills category. To make it easier for researchers to analyze the data obtained, the researchers will use the subject code in the data analysis carried out. A description of the subject code used will be presented in table 2.

**Table 2.** Subject Data Analysis Code

No.	Name	Code	Category
1.	Lulut Aprilia	SP1	Good
2.	Sunami Meilina	SP2	sufficient
3.	Rifki Syaifudin	SP3	less

From the table it is known that SP1 is a subject of research with a good problem solving ability category, SP2 is a research subject with a sufficient problem-solving skill category and SP3 is a topic of study with a less problem- solving skills category.

The three subjects that have been determined by the researchers then analyzed the ability to solve problems by working on the test of the shape of the story of the matter of the linear equation system of three variables of four questions. The story will be analyzed with the problem solving step based on the theory of John Dewey with the five stages of problem resolution: confront problem, define problem, inventory several solutions, conjecture consequence of solutions, and test consequences. The first step in this research is that three students complete a test of four questions with different language subjects. On issue number one discusses the money back on a transaction, on issue number two deals with the remains of used goods, on item number three deals about the ticket price on a match, and on item four deals on the money to be paid on the transaction. After the student completed the test, the researchers conducted interviews to learn more about the student's problem-solving skills.

After the written tests and interviews are carried out, the data obtained will be reduced in order to select the data that is considered important for further analysis. In the reduction phase of the written test and interview work data, the researcher will give a score on each step that the student can complete based on a problem-solving indicator according to John Dewey. The score of the test work and the interview performed by the student is presented in table 3.

**Table 3.** Score Results Problem-Solving Skills With John Dewey's Stages

Number of Question	Stage <i>Confront Problem</i>			Stage <i>Define Problem</i>			Stage <i>Inventory Several Solutions</i>			Stage <i>Conjecture Consequence of Solutions</i>			Stage <i>Test Consequences</i>		
	SP1	SP2	SP3	SP1	SP2	SP3	SP1	SP2	SP3	SP1	SP2	SP3	SP1	SP2	SP3
1	4	4	2	4	4	2	3	3	1	4	4	2	3	3	2
2	3	4	1	1	2	1	2	2	1	1	2	1	1	2	1
3	4	2	1	4	1	1	3	2	1	4	1	1	3	1	1
4	3	2	2	1	1	2	2	2	1	1	1	2	1	1	2

### **Stage Confront Problem**

Mathematical problems are situations that are deliberately arranged so that students gain new experiences in their mathematical understanding. The problems that are often displayed in the linear equations of three variables are closely related to everyday problems. The mathematical problem given to question number one relates to the return of a transaction, i.e.

*Aji spent Rs. 28,000 to buy 5 books, 2 bolpoints and 1 remover. Bagas spent Rs.28,000 to buy 3 books, 4 bolpoint and 2 removers in the same store. If Aini buys four booklets, two bolpoins, and two removals by giving two sheets of twenty thousand, what return does Aini receive?*

Problem Solving with John Dewey's approach begins with the confront problem Stages, which means students are invited to recognize the problem from the subject. The student's awareness that the given problem is closely related to the linear equation of three variables, suggests the concept of this material has been understood by the student.

The results of the research show that SP1 and SP2 are able to recognize the problem well and the answer given is correct. SP3 is capable of recognizing the problem but the answer provided is wrong. At this stage, Interviews are used to dig up data.. As for the conversation with SP1 as follows:

Researcher : *I mean, with the mathematics you've studied, what chapter can you use to answer that question?*

SP1 : *Oh... three-variable linear equation system Mam..*

From this conversation, SP1 was able to learn that the story is related to the matter of the three-variable linear equation system. In confronting this problem, the SP1 and SP2 undertook reinforcement of the concept by considering the mathematical material that can be used to solve the problem of the linear equation system.

In question number 2 relating to the remainder of the items that have been used, SP1 is able to recognize the problem but the answer given does not match the indicator. SP2 is capable of recognizing the problem well and the answer provided is correct. SP3 is unable to answer the question given by the researcher. In issue number 3 relates to the ticket price of a contest, SP 1 is capable to recognize the problem and the answers given are of the right value. SP 2 is able to recognize a problem but an answer given is incorrect. SP 3 is not able to answer questions given by researchers.

From the above statement it is known that the ability to solve problems at the stage defines problems in each student differently. As the opinion (Suharnan, 2005) "This difference depends heavily on the substance of the problem especially in its appearance, the information surrounding the issue, and the familiarity of a person to the issue". The difference can be due to how often students in doing the practice about recognizing the problem well. The student's ability to confront problems, help the student to understand the context of SPLTV better, and hope to be able to formulate the right solution.

### **Stage Define Problem**

Once students recognize the problem, they need to define the problem faced more specifically and clearly. At this stage the understanding gained about SPLTV enables the formulation of the correct solution dam effective. To be able to define a problem is necessary to gather more in-depth data and disaggregate the problem into smaller components or parts. The student's belief in confronting problems on SPLTV issues, invites students to think more deeply about the concept of SPLTV, like simplifying problems by writing them in the form of a linear equation system.

On issue number one relating to the refund of a transaction, SP1 and SP2 are able to define the problem correctly and completely, while SP3 is able to determine the problem but the answers given are incomplete. As shown in Figure 1:

Resarcher: *Can you write down what you know and what you ask?*

SP1 : *Yes mam, I can*

*Given:*

$$5x + 2y + 1z = 28.000$$

$$3x + 4y + 2z = 28.000$$

$$4x + 4y + 4z = 38.000$$

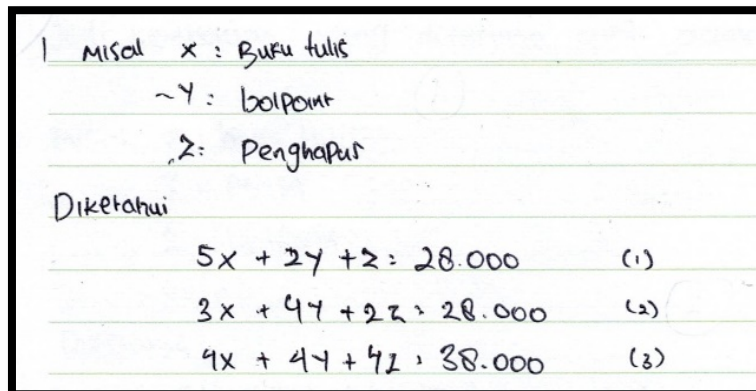
*Asked: What's the return received by Aini?*

Resarcher: *Do you understand what you're writing?*

SP1 : *yes mam, I do*

Resarcher:: *Have you ever worked or found the same or almost the same issue as number one?*

SP1 : *Yeah, I've found it and tried to work on it, once when the teacher explained the matter of the three-variable linear equation system, she gave examples of what the model was like about number one, and also an examples that given by you earlier.*



1 Misal  $x$  : Buku tulis  
 $y$  : bolpoint  
 $z$  : Penghapus

Diketahui

$$5x + 2y + z = 28.000 \quad (1)$$

$$3x + 4y + 2z = 28.000 \quad (2)$$

$$4x + 4y + 4z = 38.000 \quad (3)$$

**Figure 1.** Student Work Results Level Define Problems

From the conversation, at the stage of defining the problem, SP1 was able to recount the matter in mathematical notation. The concept reinforced at this stage is that the subject recalls, a similar subject described by the teacher, and can analogize an object with a variable. In problem solving such mathematical forms can be called mathematics modeling that represents a problem.

On issue number 2 relating to the remaining items that have been used, SP1 and SP3 were unable to define the problem at all, whereas SP2 was able to define a problem but the answer given was incomplete. On question number 3 relates to the price of a ticket to a game, SP 1 was capable of defining the problem correctly and comprehensively, while SP2 and SP 3 could not define the issue at all.

However, from the description above, it can be seen that most of the students are less able to define problems well. Students who are in the lower category tend to have not understood the subject. The student's ability to reflect on the complex relationship between real problems and mathematics reflects positive results in creating a realistic mathematical model (Căprioară, 2015, p. 1863). At this stage, the concepts are based on linear equations, variables, and linear system of equations. One of the factors causing errors in the creation of mathematical models is the lack of accuracy when reading questions. From the opinion of such accurate reading becomes the influence for students in doing past the stage of

defining problems that are then poured in the form of writing about the problems acquired. This is because students are not careful in reading (Suryanti et al., 2020) can also students not concentrate in reading so from the subject matter presented there are some things that are missed, in addition to reading writing activities also affect the ability of students in writing things that found.

### **Stage Inventory Several Solution**

At this stage, solving mathematical problems on three-variable linear equation systems requires a variety of assumptions of potential solutions based on the results of problem identification and model definition. Brainstorming activities by digging knowledge into the methods of completion of SPLTV such as the substitution method, the elimination method, and the graphic method, can help students make hypotheses.

The results of the study showed that in question number 1 relating to the return of money of a transaction, SP1 and SP2 were able to develop the hypothesis by answering the question correctly, while SP3 was unable to answer the question given by the researcher at all. In question number 2 related to the remainder of the goods that have been used, SP2 and SP1 were able of developing the hypothetics but the answer given was not accurate with the indicator, whereas SP3 is unable of answering at all the questions given by researchers.

Researcher: *Any step we can take to solve issue number three.?*

SP1 : *By solving substitution and eliminating variables*

Researcher: *What's the initial step you used when answering the question number three??*

SP1 : *Eliminates the  $x$  value on equation 2 and 3*

Researcher : *Why did you choose to eliminate the value of  $x$  on equation 2 and 3?*

SP1 : *Because at equations 2 and 3 it's clear that the value of  $x$  is the same. So I chose that's the only thing that the eye can see to be done first.*

At this stage, SP1 can describe the steps to be selected for troubleshooting. The mathematical concept reinforced at this stage by SP1 is to use the mathematics principle in completing operations with the elimination of  $x$  values. SP1 and SP2 were able to develop the hypothesis but the answer given was not accurate with the indicator, while SP3 was not able to answer the question given by the researchers at all.

The results of research are quite a lot of students who are less able to gather the solution to the problem presented by the question. This is due to the lack of knowledge and experience of students in solving a variety of issues. It takes even more practice that students do in solving problems because with practical activities students become accustomed to solving the problems resulting students will be more responsive in facing a variety of different problems.

Describe the ability to develop hypotheses that students possess in a variety of ways. The ability to develop such hypotheses can be improved by the way students multiply exercises working on various kinds of issues so that the ability of the students can be enhanced. Bair revealed that experiential factors such as age, maturity, mathematical experience, and the level of familiarity with methods, context and content became one of the factors in problem-solving ability (Căprioară, 2015).

### **Stage Conjecture Consequence of Solutions**

At this stage, students carry out consequences or considerations of each solution identified, analyzed and predicted. The test results of these hypotheses make students evaluate the methods chosen, such as faster, more confident of the truth of the results, and easier.



SP1 and SP2 are able to test the hypothesis and the answer given is the true value, while SP3 is capable of testing the hypothesis but the answers given are mostly the wrong value. In the case of number 2 relating to the remainder of the goods that have been used, SP1 & SP3 are unable to test any hypotheses at all, whereas SP2 is able to Test hypothesizations but mostly false answers.

Eliminasi  $z$  dengan Operasi pada Persamaan 1 dan 2

$$\begin{array}{r} 5x + 2y + z = 28.000 \quad | \times 2 \\ 3x + 4y + 2z = 28.000 \quad | \times 1 \\ \hline 10x + 4y + 2z = 56.000 \\ 3x + 4y + 2z = 28.000 \\ \hline 7x = 28.000 : 7 \\ x = 4000 \end{array}$$

Eliminasi  $x$  dengan Operasi pada Persamaan 2 dan 3

$$\begin{array}{r} 3x + 4y + 2z = 28.000 \quad | \times 4 \\ 4x + 4y + 4z = 38.000 \quad | \times 3 \\ \hline 12x + 16y + 8z = 112.000 \\ 12x + 16y + 12z = 114.000 \\ \hline -4z = -2.000 \\ z = -2.000 : -4 \\ z = 500 \end{array}$$

Substitusikan nilai  $x$  dan  $z$  ke Persamaan 1

$$\begin{array}{l} 5x + 2y + z = 28.000 \\ 5(4000) + 2y + 500 = 28.000 \\ 20000 + 2y + 500 = 28.000 \\ -2y \quad 20.000 + 500 + 2y = 28.000 \\ 20500 + 2y = 28.000 \\ 2y = 28.000 - 20500 = 7500 \\ y = 7500 : 2 = 3750 \end{array}$$

**Figure 2.** Student Results Testing Hypotheses

Based on the description of the ability to test the hypotheses that various students have, most of them make conceptual errors (Cahyani et al., 2021) either in the middle of the activity or on calculation errors. The activities that students undergo at this stage are not just once but many times until the desired goal is achieved. Ability seen in the test phase of the hypothesis includes the ability to determine and adjust measures considered both by the student and the computing ability that requires a very high degree of rigour because the result will be obtained is not only one and between the results there is a correlation. This is in line with Gagne's view (Wahyudi & Anugraheni, 2017) that "to drop a hypothesis and work to get a result, the result may be more than one".

Researcher: *What's your next step??*

SP1 : *I eliminated y with surgery on equation 1 and 2*

Researcher: *How do you eliminate it?*

SP1 : *I'm returning this, so the y value above I multiply by the equation below thus the value below y I multiplied by that equation above. Then the decrease is decreased and the result is  $x = 4,000$*

From the description of the ability to test hypotheses things that can influence in passing the stage of testing the hypothesis that is the rigour of the student in working every step and calculation, determine the best completion step and conform to the purpose and good calculation in each operation. In passing this stage, the results obtained by the students are not just one and the correlation between the results of the steps is very close. At this stage of the hypothesis, algebraic concepts and principle of elimination are reinforced to solve problems to acquire  $x$ ,  $y$ , and  $z$  values.

### Stage Test Consequences

SP1 and SP2 are able to test the hypothesis and the answer given is the right value, while SP3 is able to take the best hypothesis and do the verification but the given answer is the wrong value. In the issue of number 2 relating to the remainder of the goods that have

been used, SP2 and SP3 are unable to accept the best hypotheses and do verification at all, whereas SP2 is capable of taking the best theory and performing verification and the given answers are wrong.

Based on the description of the ability to take the best hypotheses and verification possessed by students of various kinds. The student's activities in this phase are related to the previous phase of testing the hypothesis. In this phase the student performs a re-checking of the answers obtained so that the student takes the best hypothesis-hypothesis from the answer. During the problem solver, students as individuals define hypotheses, acquire new information and gradually discover which circumstances influence or become solutions to problems. After choosing the best hypothesis the next student performs a verification of the statements already listed in the question. Here is one example of the student's work at the stage of taking the best hypothesis and verification studied in Figure 3.

Handwritten student work showing a calculation of  $1 \times 4000 + 2 \times 2500 + 2 \times 3000 = 27.000$  and a subsequent calculation of  $40.000 - 27.000 = 13.000$ .

**Figure 3.** Student Results Level Taking Best Hypothesis and Verification

From the description of student problem-solving skills to the stage of taking the best hypotheses and verification, student skills vary greatly. The ability to re-examine the answers obtained, the ability to take the best hypothesis from some of the hypotheses acquired, and the capacity to complete the verification phase.

Problem-solving strategies, one of the alternatives that teachers can choose to strengthen the student's mathematical concepts. Problems solver on mathematics, effective for contextualization and recontextualisation of concepts, for transfer of operational and basic mathematical knowledge for sustainable and meaningful learning (Căprioară, 2015). On the matter of three variable linear equation systems, that mathematical concept has been reinforced by John Dewey's problem-solving strategy, namely, knowledge of the context of mathematics in everyday life, simplifying problems by doing mathematic modeling, choosing alternative solutions to help students in recalling the materials they have ever studied. The concepts of mathematical thought increased on the conjecture for the solution of hypotheses, at this stage the principles of algebra, elimination or substitution, and accuracy in calculation were executed, then at this phase many students failed to solve problems or errors in calculations. The result obtained must be tested for truth, by substituting the result to a linear equation. Once again reinforced mathematical concepts that will be embedded into a habit in any problem solving. This result is in line with the goal of Problem Based Learning which is to train students to find answers on their own and through the process of problem solving to develop abilities and transform abstract concepts and knowledge into practical and applied solutions. (Chen, 2008).

## CONCLUSION

Based on the research that has been discussed, it can be concluded that the ability of students in solving story problems with the John Dewey approach is known that of the four

stories, problem solving related to issue number one, three research subjects were able to solve the problem but in SP3 were unable to resolve the solution of the problem at several stages, namely the development of problems, testing the hypothesis and taking the best hypotheses and verification. In question number 2 relating to the remainder of the goods that have been used, of the three students only one student namely SP2 was able to Solve the Problem Solving but at the stage of testing the hypothetics and take the best and the verification of the results obtained by SP2 is wrong. But both of the other students were unable to complete the problem-solving phase. As for the matter of money to be paid on a transaction. Only one student is able to solve the problem solving, which is SP3, although it is only capable of solving the phase of defining the problem and defining it. Whereas at the stage of developing the hypothesis, the test of the problem phase and the stage taking the best hypotheses and verification of SP3 is capable of resolving the problem but the answer given is worth the wrong.

According to the results of the study, the researchers suggested the following: Students should do more of the various kinds of questions practices. The questions used in the practice are the questions given by the teacher or the questions found from other sources. They should be able to improve their skills by increasing their ability to work with different cases, so that their skills can be developed. They should deepen their skill in calculation by working with different subjects.

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