

Analysis of Student Thinking Processes in Mathematical Problem Solving using Saintificial Approach

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Abstract—The scientific approach emphasizes the ability of students to process information through various observing and communicating activities. This certainly requires a thought process to answer problems in learning mathematics. This study aims to find out the students' thinking process in solving mathematical problems through a scientific approach. The research method used is explorative research with qualitative descriptive data analysis techniques. The results show that the scientific approach contributes to developing students' thinking process.

Keywords—scientific approach, mathematical problems, thinking process

I. INTRODUCTION

Mathematics is a field of science that can improve students' thinking process. It can be seen when students can solve mathematical problems. Knowledge can be possessed by students if themselves actively. This method requires students to actively use their experience of connecting with the knowledge that will be formed. As we know that, almost all of activities always involve a memory. Therefore, memory becomes something that very important in the thinking process of everyone [1]. Memory is more related to the brain that maintenance everyone memory process. To find out the involvement of students active in the learning process, it is not enough to know their achievements in learning outcomes. It needs more to be observed on how students learn because learning is an activity that related to the thinking process. In this case how students process their information. If the students make a mistake when processing their information than the teacher can fix it. This relation with the opinions of several educational psychologists [2], by standing the knowledge and understanding of learning not only explains why students succeed in learning, but also helps them to prevent irregularities during learning so that they can be corrected. Sometimes students have a problem, and they want to solve it but they cannot because there are not available hint to reach a goal. The goals to be achieved can be in the form of adjustments to new situations or completion of tasks.

Polya in Mataheru [3] says that the problem is divided into two, namely finding the problem and proving the problem. Finding problem is a theoretical or practical, abstract or concrete problem. The main parts of the problem

to find, include: the question of what are you looking for? how is the data known? what is the condition? While the proves a problem to be a problem to indicate whether a statement is true or false or not both. This can be done by answering the question of whether the statement is true or false? The main part of this problem is the hypothesis and conclusion of a theorem that must be proven. Thus, a mathematical question can be a problem for someone, depending on how to solve the problem. Therefore, it is very necessary to think complexly of the person to think about how to solve the right problem.

According to Johnson & Rising in Mataheru [3], mathematical problem solving is a complex mental process that requires visualization, imagination, manipulation, analysis, abstraction, and coherence of ideas. Mathematical problem solving cannot be separated from one's knowledge of the substance of the problem. For example, how are students understanding of the core of the problem, what the steps are used and which rules are appropriate to be used in solving the problem or understand problems? Polya divides problem-solving into four steps, namely: (a) Understand the problem. In this step, students must be able to show the important parts of the problem, that is, what is known or unknown? what is being asked? what do the terms mean? the conditions are given in the problem. Therefore the teacher's question to students, what is known? what is being asked? Is there enough information or is more information needed? (b) Thinking time: devise a plan. In this step, the idea of the plan needs to be considered. Good ideas are based on prior experience or information. Therefore the question asked is that is this problem related to something? If it doesn't work, you can change the form of the problem or modify the problem, by asking if you can state this problem? (c) Insight (carry out the plan). In implementing the plan that has been designed, the teacher must ask students to examine each step by asking if you are sure that the step is correct? (d) verification: look back. When a solution is found, it is necessary to check to see if it works. The question asked is that you can check the results? Can you check the argument? To provide challenges and satisfaction in solving problems can be asked questions, namely, can you get results in a different way?. If you find that your solution does not work, there may only be a simple mistake. Try to fix or modify your current attempt before scrapping it. Remember what you tried—it is likely that at least part of it will end up being

useful. Is there another way of doing the problem which may be simpler? (You need to become flexible in your thinking. There usually is not one right way.) Can the problem or method be generalized so as to be useful for future problems?

Problem-solving can be characterized as a thinking process that requires effort and concentration of mind, because in order to get the answers to problems. It must be built from the information available in memory. Most students think that problem solving is a difficult thing because to solve it students must use prior knowledge in accordance with the information received. This is an input for the teacher to know what prior knowledge of the students and when they are solving problems, so that the teacher can design teaching and learning process based on the knowledge that students already have. In connection with this, Jones [4] has experience as a mathematics teacher; he found that problem solving is a difficult task for many students, especially when recalling information.

Van Someren et al. [5] state that a student's thinking process can be stated as information processing. According to Marpaung in Mataheru [3], the process of thinking is a process in one's mind (which cannot be observed directly, but can be examined in certain ways or methods), from when receiving data, then processing it, then storing it in the form of information in memory and call it back from memory when they needed in the course of further data processing.

From the meaning of thinking process, then we can state that thinking process in this research is information processing activities in students' minds which include: receiving information, processing information, storing information, and recalling information from memory when needed for later use. Based on information processing theory it can be said that: (a) receiving information is obtaining certain information from the environment to be processed later, (b) processing information is an effort to associate previous knowledge with information received, (c) storing information is maintaining information accepted and retained prior knowledge in memory, and (d) recalling information is remembering information received and remembering prior knowledge. Information processing is related to the scientific approach.

Processing information is related to the scientific approach. Schrader & Brown [6] said the scientific approach as a scientific approach is believed to be a golden platform for the development and development of students' attitudes, skills, and knowledge. The term scientific approach or scientific approach is the subject of discussion that attracts the attention of teachers. The application of this approach is a challenge for teachers through developing student activities. According to Baek [7], the scientific approach is an approach in the learning process where students are invited to observe an object to be studied and given the opportunity to make questions arising from their observations, then students are given the freedom to experiment with their scientific experience and manage the results of the experiments carried out, also expected students are able to present and draw conclusions from what has been learned, besides that students can also create something that is collected from scientific facts possessed.

Sufairoh [8] stated that the learning process that refers to the scientific approach according to the Ministry of

Education and Culture covers five steps, namely: observing, asking questions, collecting data, associating, and communicating. Description of steps in the scientific approach to learning the 2013 curriculum as follows. (a) Observing: Students read, hear, listen, see (without or with tools) to identify things they want to know. Observe with the senses (reading, listening, listening, seeing, watching, etc.) with or without tools; (b) Question: Students ask questions about things that are not understood from what is observed or questions to get additional information about what is observed. Create and ask questions, answer questions, discuss information that has not been understood, additional information that you want to know, or as clarification; (c) Trying / collecting data (information): Students conduct experiments, read other sources and textbooks, observe objects / events / activities, interview with resource persons. Exploring, trying, discussing, demonstrating, imitating forms, doing experiments, reading sources other than textbooks; (d) Associate / process information: Students process information that has been collected both limited from the results of collecting or experimenting activities and the results of observing and gathering information, processing information that has been collected, analyzing data in the form of categorizing, associating or linking phenomena or connected the information in order to find a pattern, and conclude; and (e) Communicate: Students submit observations, conclusions based on the results of the analysis verbally, in writing, or other media. Presenting reports in the form of charts, diagrams or graphs; compile a written report; and present reports covering the process, results and conclusions orally. So, it can be concluded that the scientific approach is a learning process that includes five steps, namely: observing (M1), asking (M2), gathering information (M3), processing information (M4), and communicating information (M5). Based on the description above, this study aims to determine the thinking process of students in solving mathematical problems through scientific approaches.

II. RESEARCH METHODS

A. *Types of research*

This type of research is exploratory research with a qualitative approach. Exploratory research is that researchers want to explore deeply about things that affect the occurrence of something [9]. Whereas research with a qualitative approach is research whose research procedures produce descriptive data in the form of written or oral words from people or observable behavior [10].

B. *Research subject*

The subject of the study was a grade VIII student of SMP Negeri 7 Ambon who was of moderate ability. Criteria for selecting research subjects, namely: (1) based on test scores on learning outcomes, and (2) requesting teacher's consideration of whether the chosen subject has a score that is appropriate to his daily abilities in his class and can express his opinion orally or in writing?

C. *Research Instruments and Data Collection Procedures*

The research instrument is the main instrument (researcher) and supporting instruments in the form of problem-solving tasks and interview guidelines. The interview guidelines used are semi-structured interview guidelines. After completing the interview, an interview

transcript was made for the research subject, using the following code. Q: Questions from researchers; while S: answer from subject i; and Tij is ordering of transcript while ...: Pause.

Data collection procedures are as follows. (a) The researcher gives the problem-solving task to the subject, (b) the researcher provides the opportunity for the subject to understand the problem and plan problem solving, (c) the researcher interviews the subject to find out how the subject understands the problem and how the subject plans the problem solving, (d) The researcher gives the opportunity to the subject to solve the problem, and (e) the researcher interviews the subject to find out how the subject gets a solution and how the subject re-examines the results obtained.

D. Data Analysis Technique

Data analysis includes analyzed problem-solving tasks and interview data. Data problem-solving tasks are analyzed based on the subject's answers in writing, with regard to several things. For example, how the subject understands the problem; concepts, operations, or what formulas / characteristics are used in solving problems; and whether students correct their completion; while the interview data is analyzed based on the respondent's verbal response. The analysis is carried out at each step of problem-solving, taking into account the indicators of the thinking process. The results of the interview data analysis are used to strengthen the findings in problem-solving in writing so that the subject's thinking process can be properly expressed. This research data was analyzed by data reduction, data presentation, and withdrawal conclusion.

III. RESULTS AND DISCUSSION

The problem-solving task instrument was validated by an expert in the field of mathematics education and three mathematics teachers. From the results of the validation, the validator provides recommendations that the problem-solving task is worthy of use. Instrument testing of problem-solving assignments was given to three class of eighth-grade students of SMP Negeri 7 Ambon. They come from medium-ability groups in their class, so understanding of the tasks given is an average understanding of students in the eighth grade of SMP Negeri 7 Ambon, as well as for eight grade students in other junior high schools. From the results of the field test shows, students can interpret the core of the problem. Thus the instrument of problem-solving tasks has fulfilled the legibility test so that the instrument can be given to the research subject.

The interview guideline instrument was prepared based on the results of consultations with researchers with colleagues and junior high school teachers. Colleagues are involved in the consultation because they are considered to have the ability to understand the thinking process. While junior high school teachers are involved in the consultation because they better understand the everyday language of students in school. Consultation is carried out by paying attention to the suitability between the questions and the purpose of the interview.

In conducting the interview, the question of the researcher is not only based on the interview guidelines that have been compiled but also adjusted to the answers put

forward by the subject. This is because it is ascertained that the subject's unexpected response appears, so the interview question is based on the condition of the subject being interviewed. The problem is given to the subject in the form of , which is " Calculate how long of a piece of wire when it uses to make the edges of a cuboid (rectangular prism) with dimension 10 cm, 8 cm, and 9 cm.

!" The following is the subject thinking process in problem-solving through a scientific approach.

The scripts can show how the students are thinking process:

- T01 Q : Have you read the assignment?
T02 S : Already (read silently, while underlining the words read).
T03 Q : Why did you underline those words?
T04 S : because I will try to remember.
T05 Q : Why don't you underline all the words?
T06 S : Because it is not important (underlining a few words that are known and asked).
T07 Q : Do you understand the task?
T08 S : Yes I do.
T09 Q : If you understand the task, what is known?
T10 S : The wire has length 10 cm, width 8 cm, and height 9 cm.
T11 Q : What the question?
T12 S : Calculate the length of wire to make the cuboid frame
T13 Q : How do you know?
T14 S : Hmm... from the question I know that knowing problem means available information and question means that asking something...
T15 Q : Where do you know that?
T16 S : Teacher.
T17 Q : Do the teacher said that?
T18 S : Yes I do. I still remember
T19 Q : Can you write down what is known and what is asked?
T20 S : Yes (write without looking at the assignment sheet).
T21 Q : Why do you write without looking at the assignment sheet?
T22 S : Because I still remember.

From the interview scripts above, the subject reads silently while underlining the words (T02). The subject gave the reason why he underlined the words that were read, namely so that he could remember what was read. Means that there has been a process of information stored in the sensing register, so that information is temporarily not lost.

Not all words contained in the task are underlined, but only a few words are considered important (T06). This shows that there has been a selection of information received because the subject directs focused attention to the information received while ignoring other disturbing stimulation. The underlined words have a unity of meaning because he underlines important words included in the group known and in the group being questioned. This shows that the information received has been perceived by the subject because he has interpreted or interpreted the information received into a single meaning that is ready to be processed in working memory. Thus the subject has received information by reading without voicing while underlining the words read. In the interview snippet (T14), the subject says that what is known means telling something and being asked means asking something. The subject gets this understanding from his teacher. This shows that the subject has interpreted what is known and who is asked. Thus the subject has recalled the information by saying the previous knowledge about the meaning known and being asked. Next, the subject said what was known and who was asked. Then he wrote it down without looking at the assignment sheet because he still remembered. This is because he directs focused attention to the information received. Thus the subject processes information by checking the sentences contained in the information received. He said, the sentence that tells about something shows what is known and the sentence that asks about something shows what was asked. In addition, he has kept information because he has done repetition by writing down what is known and what is being asked. Based on the results of the interview data analysis it was concluded that the subject's thinking process in understanding the problem as follows. (1) receive information by reading silently while underlining the words that are read (see / M1); (2) recalling information by saying prior knowledge about the meaning known as telling something and being asked as asking something (gathering information / M3); (3) processing information by checking the sentences contained in the information received. He said, the sentence that tells about something shows what is known and the sentence that asks about something shows what was asked (processing information / M4); and (4) storing information by means of repetition, namely writing down what is known and what is being asked (communicating information / M5).

Interview Data on Steps to Plan Problem Solving

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- T23 Q : What was the first time you thought before completing this task?
- T24 S : Must use multiplication and addition.
- T25 Q : Why do you say that?
- T26 S : Because it was asked here, ... the length of the wire needed on the beam.
- T27 P : So how are you?
- T28 S : Mother ... do I have to use distributive properties?
- T29 P : If you use distributive law, how do you do it?
- T30 S : $4(p + l + t) = 4p + 4l + 4t$
-

Based on the interview footage, the subject said that the task could be completed using multiplication and addition operations (T24) because it was asked the length of the wire needed on the beam. The subject is still hesitant to determine the properties used, so he asks again "do you have to use distributive properties?" (T28). So it must use distributive properties (T30). This shows that it has recalled information by saying prior knowledge about distributive properties. In addition, he also has stored information by repeating steps to understand the problem, which is to say information received, so that information can be recalled for use.

From the results of the interview data analysis, it was concluded that the subject thinking process in planning the problem solving as follows. (1) recall information by asking the teacher about distributive properties (M2); and (2) processing information by saying distributive properties $4(p + l + t) = 4p + 4l + 4t$ (M4).

Written Job Interview Data on Steps to Solve Problems As Planned

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- T31 P : How do you solve it?
- T32 S : $4(10 + 8 + 9) = (4 \times 10) + (4 \times 8) + (4 \times 9) = 40 + 32 + 36 = 108.$
- T33 Q : Do you have another way to count again or not?
- T34 S : Got it.
- T35 Q : How are you doing?
- T36 S : $4(10 + 8 + 9) = 4(27) = 108.$
- T37 Q : Why do you use the second method?
- T38 S : Because the results remain the same, which is 108.
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From the written job interview data, the subject resolves the problem according to the plan, which is stated as $4(10 + 8 + 9) = (4 \times 10) + (4 \times 8) + (4 \times 9) = 40 + 32 + 36 = 108$ (T32). This shows he has recalled information using the planned method. Means that he also has stored information by doing repetition in the completion planning steps, namely using the planned method. Then he uses another method, namely $4(10 + 8 + 9) = 4(27) = 108$ (T38). This shows that the subject has processed information in two ways.

Based on the results of the written work data analysis, it was concluded that the subject's thinking process in solving the problem according to the plan as follows. (1) recall information using the planned method for problem-solving planning (M3); (2) processing information using two ways (M4).

Interview Data on Steps to Re-Check Results Gained

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- Q39 Q : Are you sure that the steps taken are correct?
- T40 S : Sure, because the length of wire needed is in accordance with the completion, which is 108 cm.
- T41 P : How to check it?
- T42 S : I already used two ways that the results are correct. So I am sure that my answer is correct

(check during work and after obtaining the final result).

T43 P : Now what do you think about the results obtained?

T44 S : My opinion about the results obtained is that my answer is correct for the two ways.

Data Analysis Interviews on Steps to Re-Check Results Gained

Interview footage (T40) shows that the subject has re-examined the work contained in the step to solve the problem according to plan. This is done both during the settlement process and after obtaining the final results. This shows that the subject has saved information because it has made repetitions at the completion steps that have been passed. Next in the interview snippet (T42), the subject said his opinion that the two methods he used were correct and the truth had been checked. This indicates that the subject has saved information.

Based on the results of the interview data analysis it was concluded that the subject's thinking process in re-examining the results obtained as follows. (1) the subject has stored information by Doing repetition on the step of solving the problem according to plan, which takes place during the completion process and after obtaining the final result (M4), and organizing the results obtained are marked with the same final result (M5).

Discussion Formulation of students' thinking processes in solving mathematical problems through a scientific approach, begins with analyzing the thought processes that arise at each step of problem-solving. The analysis is carried out based on indicators of thought processes and indicators of scientific approaches. At the step of understanding the problem, the subject receives information by reading (M1), while underlining the words that are considered important. This shows he is observing and repeating to remember the information received. Repetition like this can be said to be a complex repetition. Arends [11] stated complex repetition needs to make efforts that are further than just repeating information, for example underlining key ideas. Furthermore, the subject processes information by checking the sentences contained in the information received. The subject said, the sentence that tells about something shows what is known and the sentence that asks about something shows what was asked. Thus the subject has recalled information by remembering prior knowledge of the known and questioned meanings, associated with the information received so that he can say what is known and what is asked (M3 and M4). At the completion planning step, the subject plans a settlement in accordance with the information received. This means that the subject has been successful in processing information, because it has directed focused attention to the information received, in this case, it has not failed (M4). In the opinion of Woolfolk et al. [12], failure to process information will mean the loss of perception and attention to ensure that important aspects are registered. At the step of solving the problem, the subject resolves the problem in two ways of solving, namely using distributive properties and completing the sum of the numbers in parentheses then multiplying them by the first term. This is in accordance with Putra's opinion [13], long-term memory

as well as libraries, of course, requires a system to regulate stored information. Information systematics is very helpful in the process of recalling information. When solving a problem, the subject uses two ways. The first way, as planned. This means that it stores information by repeating steps for completing planning, namely using the planned method, so that the method can be recalled for use. The second way, obtained after he completed the first method. This means that the first way can provide a deeper insight to get a second way. Therefore he must recall the previous knowledge related to the information received for processing (M3 and M4).

At the step of checking the completion again, the subject says the first method of settlement is the same as the second method of completion (M5). This shows that the subject has saved information because it has done repetition on the steps to solve the problem according to the plan that has been passed and said coding of the results obtained. According to Miller [14], in long-term memory, information can be stored more permanently, which is done by repeating or organizing information in known groups. Repetition is done, able to improve information recall, because of the activity of strengthening relations between information. The more often the subject uses a single information path, the path in question is strengthened in memory. As a result, the subject's mind is easier to access various information on the pathway.

IV. CONCLUSION

The process of thinking of students in solving mathematical problems through the scientific approach as follows. Subjects observe by reading information (M1), information that the subject has not yet known is done by asking (M2), the subject collects information by recalling previous information (M3), the subject processes information by using available information (M4), and the subject communicates information by restating the information that has been obtained (M5).

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