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STUDENTS' ABILITY TO SOLVE MATHEMATICAL PROBLEMS THROUGH POLYA STEPS

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Abstract

Students' mathematical problem-solving skills are still low, and students are not yet familiar with such problems. This research describes students' ability to solve mathematical problems, especially geometry, based on the Polya stages. The research design uses a qualitative approach with 40 students of Besitang 1 State Junior High School students. Case studies become data analysis techniques; then, data analysis is carried out by reducing, presenting, and verifying data. Finally, check the validity of the data by triangulating the data source. The results of the analysis obtained that students' ability to understand the problems and devise a plan was at intervals of 3 as much as 60% with good categories, carrying out the plan at intervals of $1 < x \leq 2$ as many as 73% of categories is sufficient and looking back at intervals of $0 < x \leq 1$ as much as 78% of categories are not good. It is recommended that advanced educators and researchers train students to solve mathematical problems, especially the stages developed by Polya. This ability is the second intelligence in mathematics after students have the first intelligence to understand mathematical concepts.

Keywords: Mathematics problems, Mathematical problem-solving, Non-routine problem, Polya Steps, Students' ability.

1. Introduction

Junior high school students are expected to have the ability to solve mathematical problems because this ability is essential to have improvement of junior school students in learning mathematics [1, 2]. One of the abilities in the standard mathematical process is solving mathematical problems. Problem-solving is a mathematical learning activity, the main means to develop understanding in learning mathematics, students' initial knowledge, skills, and starting points in teaching mathematics [3, 4]. Problem-solving can make students understand mathematics learning, encourage students to solve problems, and students skills to learn other materials in mathematics [4, 5]. The ability to solve mathematical problems becomes an essential ability in mathematics. In addition, in the 2013 curriculum, the Indonesian government also listed the importance of mathematical problem-solving. Problem-solving is also highly desirable in the 21st century because as a component in learning mathematics that trains the skills of mathematics and becomes the desired graduate in jobs [6].

Students' ability to solve mathematical problems is low. Students are not yet familiar with math problems that measure the ability to mathematical problem-solving. The problem given is not a non-routine problem. It is still foreign to students if there are non-routine problems. Teachers are still used to giving students regular problems by giving further examples of exercises similar to examples. When given the initial test, students are confused to see a form of the problem that is not what the teacher usually gives. Students view mathematics as a difficult field of science because the teaching of mathematics is not engaging. Students do not respond well to lessons and feel boring math learning, the selection of learning methods is not diverse, still focusing on the teacher as the giver of everything makes students passive in learning mathematics, and lack of media to learn mathematics [7, 8]. Learning should be student-centered, making students more active in learning. Teachers can practice thinking skills with students in problem-solving because teachers are facilitators for students [9]. Teachers can prepare students who have skills and competencies, namely by preparing effective learning and teaching [10].

Seeing the importance of students having mathematical problem-solving skills, this research aims to describe students' ability to solve mathematical problems, especially geometry, based on four stages developed by Polya.

2. Literature Review

Mathematical problem-solving skills consist of four stages [11, 12]. The stages are in the following:

(i) Understanding the problem is done by making what is known; what is enough data? Moreover, what is asked of the given problem? For example, it is known to be a rhombus and asked to find the formula for the Area of the rhombus.

(ii) devising a plan where students are directed to consider the problem from various sides, think about the right strategy to solve the problem, and see the suitability of the strategy used in solving the problem. For example, finding the Area of the rhombus of the Area of a triangle.

(iii) carrying out the plan, that is, implementing the plan or compiling a mathematical model. Students are sure to understand the problem and have found a solution strategy at this stage. Furthermore, students can solve problems without hesitation. For example, Fig. 1 shows a rhombus divided into two triangles. Based on Fig. 1, students can find the Area of the rhombus, namely: Area of the rhombus = Area of the triangle ABD + Area of the triangle BCD. Then, it is becomes $\frac{1}{2}axt) + \left(\frac{1}{2}axt\right)$. And, it becomes { $\frac{1}{2}(\underline{BD}x\underline{AO})\} + \{\frac{1}{2}(\underline{BD}x\underline{OC})\}$ and $\frac{1}{2}(BDx\left(\underline{AO} + \underline{OC}\right))$. It explains diagonal $\underline{BD} = d_1$ and $\underline{AC} = d_2$. So, the area of the rhombus is $\frac{1}{2}xd_1xd_2$.

(iv) looking back is to check the completeness of the elements, consider solutions from various sides, complete the incomplete elements and see carefully whether the previously carried out processes are correct. For example, the area of the parallelogram = area of the rectangle = 2 x area of the triangle = area of the rhombus is $axt = pxl = 2(\frac{1}{2}axt) = \frac{1}{2}xd_1xd_2$, $axt = pxl = axt = \frac{1}{2}xd_1xd_2$. with length (p) = d_1= base (a) dan wide (l) = $\frac{1}{2}d_2$ = height (t), so: $axt = axt = axt = axt$. So, it is proper that, Area of the rhombus = $\frac{1}{2}xd_1xd_2$.

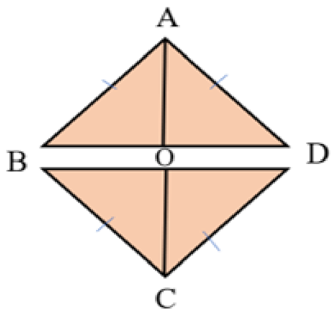

Fig. 1. A rhombus divided into two triangles.

3. Research Method

This research used an exploratory type of research with a qualitative descriptive research approach. Forty students of class VII of Besitang State 1 Junior High School, North Sumatra, Indonesia, were subjected to the study. Student selection is conducted based on repeat results, daily grades, and final exam results. Instruments in research are tests of mathematical problem-solving skills in essay problems with as many as five items. Tests before being given to students have conducted instrument trials on 30 students of class VIII. Instrument trials include validity and reliability to produce a viable instrument. This test aims to look at students' ability to solve mathematical problems based on the Polya steps. The material used in the test is a quadrilateral flat build. Case studies become data analysis techniques in research. Case studies are conducted by examining the degree of trust. We made observations using good techniques by obtaining all the necessary data as information already in the field. Furthermore, the data is analysed by reducing the data, namely reducing the data obtained from test results. The presentation of data by compiling data in the form of answers to test results that will later be made to conclude, and finally verification is done, namely making conclusion withdrawals. After the data is analysed, the data validity is checked using triangulation of data sources. We collect data from student test results are then examined and described the results of solving mathematical problems for students to problems or tests that have been given. The student's mathematical problem-solving results are described based on the maximum score of each Polya step. Table 1 is the criteria for determining the student's problem-solving process.

4. Results and Discussion

4.1. Instrument test results

Table 2 shows the results of the instrument trial in the form of validity. Based on the criteria of testing validity with a significance level of 5%, degrees of freedom = 18, obtained *t*-count = 2.05. Thus, referring to the criteria of *t*-count testing > *t*-table, then all test items can be used or valid with good test criteria. Table 3 shows obtained the total value of Cronbach Alpha increased by 0.945. Based on the data obtained, the data has very high reliability. Based on the instrument trial as validity and reliability, the test of mathematical problem-solving capabilities is worth using.

Table 1. Student troubleshooting process criteria.

Polya Steps	Mathematical Problem-Solving Process Indicators	Value Interval	Category Valuation
Understanding the problem	Complete completion steps and correct answers	3	Good
	Incomplete completion steps and correct answers	$1 < x \leq 2$	Enough
	Incomplete settlement steps and incorrect answers	$0 < x \leq 1$	Less Good
Devising a plan	Complete completion steps and correct answers	3	Good
	Incomplete completion steps and correct answers	$1 < x \leq 2$	Enough
	Incomplete settlement steps and incorrect answers	$0 < x \leq 1$	Less Good
Carrying out the plan	Complete completion steps and correct answers	3	Good
	Incomplete completion steps and correct answers	$1 < x \leq 2$	Enough
	Incomplete settlement steps and incorrect answers	$0 < x \leq 1$	Less Good
Looking back	Complete completion steps and correct answers	1	Good
	Incomplete settlement steps and incorrect answers	0	Less Good

4.2. Research results

Based on the formulation of each test item obtained the results of the analysis of the problem-solving process in solving the mathematical problem. Some student problem-solving processes are analysed descriptively.

Table 2. Correlation of trial results validity and different power.

Item		Item_1	Item_2	Item_3	Item_4	Item_5	Total
1	Pearson Correlation	1	0.770**	0.728**	0.710**	0.783**	0.882**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
	N	30	30	30	30	30	30
2	Pearson Correlation	0.770**	1	0.775**	0.869**	0.776**	0.926**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
	N	30	30	30	30	30	30
3	Pearson Correlation	0.728**	0.775**	1	0.743**	0.846**	0.901**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000
	N	30	30	30	30	30	30
4	Pearson Correlation	0.710**	0.869**	0.743**	1	0.802**	0.909**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000
	N	30	30	30	30	30	30
5	Pearson Correlation	0.783**	0.776**	0.846**	0.802**	1	0.921**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000
	N	30	30	30	30	30	30
Total	Pearson Correlation	0.882**	0.926**	0.901**	0.909**	0.921**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	
	N	30	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed)

4.2.1. Understanding the problem

All students answered questions number 1, 2, 3, 4, and 5 correctly and most of them achieved maximum scores. Based on understanding the problem stage, the majority of the students were able to note what they knew and described them completely and correctly. The problem-solving process at the stage of understanding the problem is at interval 3 for good categories. The number of students who answer the problem with a complete and correct completion step there are 24 students (60%). Good categories at intervals of $1 < x \leq 2$ are students who answer questions with preliminary steps and correct answers; 13 students (33%). In the unfavorable category at intervals of $0 < x \leq 1$, students who answer questions with preliminary steps and incorrect answers there are 3 students (8%).

4.2.2. Devising a plan

All students answered questions number 1, 2, 3, 4, and 5 correctly and most of them achieved maximum scores. Based on devising a planning stage, the majority of the students were able to could write techniques used to solve the problem correctly and only some students did not write how to solve the problem at all. The indicator stage of devising a plan is at interval 3 for good categories: students who answer questions with complete and correct completion steps and 24 students (60%). Good categories at intervals of $1 < x \leq 2$ are students who answer questions with preliminary steps and correct answers; 13 students (33%). In the unfavorable category at intervals of $0 < x \leq 1$, students who answer questions with preliminary steps and incorrect answers are 3 students (7%).

Table 3. Item-total statistics.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item_1	56.77	573.082	0.851	0.790
Item_2	56.23	568.116	0.906	0.785
Item_3	56.23	572.599	0.876	0.789
Item_4	56.77	572.392	0.886	0.788
Item_5	56.00	591.103	0.905	0.797
Total	31.33	177.126	1.000	0.945

4.2.3. Carrying out the plan

Some students achieved maximum scores and write settlements that present correct and complete results, while some others did not write how ways to solve the problems. Some of them wrote the settlement with the correct but incomplete results. The stage of carrying out the plan at interval 3 for good categories is students who answer questions with complete and correct completion steps; there are 8 students (20%). Good categories at intervals of $1 < x \leq 2$ are students who answer questions with preliminary steps and correct answers; 29 students (73%). At the same time, the unfavorable category is at intervals of $0 < x \leq 1$, namely students who answer questions with preliminary steps and incorrect answers there are 3 students (7%).

4.2.4. Looking back

Looking back students were less than good because more students were conducting incomplete tasks and the answers were incorrect. The stage of looking back at interval 1 for good categories is students who answer questions with complete and correct completion steps; there are 9 students (22%). The disadvantaged category is students who answer questions with preliminary steps and incorrect answers; 31 students (78%). Thus, the number of students who obtained the criteria of the problem-solving process at the stage of understanding the problem is at intervals of 3 for good categories, and the number of students who answer questions with complete and correct completion steps there are 24 students (60%). The stage of devising a plan is at interval 3 for good categories: students who answer questions with complete and correct completion steps; 24 students (60%). The stage of carrying out the plan at intervals of $1 < x \leq 2$ with sufficient theory is students who answer questions with preliminary steps and correct answers as many as 29 students (73%). The stage of looking back at interval 0 for the category is not sound, namely, students who answer questions with incomplete completion steps and incorrect answers as many as 31 students (78%). Based on the value interval, then to the stage of understanding the problem and devising a plan is in a suitable category, solve the category carrying out the plan enough and looking back the category is not good. It can be concluded that students still have difficulties in solving mathematical problems at the stage of looking back.

Based on the study results, students need to habituate by training problems in mathematical problem-solving skills and selecting learning models following the

Polya stage. Habituation and selection of such models are expected to increase students' ability to solve mathematical problems. Mathematical problems are non-routine problems given to students. Non-routine problems that students are not accustomed to can make it difficult for learning mathematics. However, non-routine problem-giving can make students accustomed to solving problems related to mathematical problem-solving skills. Non-routine problems that are constantly trained and accustomed to students, then over time, students will understand and find their solutions to mathematical problem-solving. When students have found their solutions, this makes students challenged to solve other mathematical problems going forward. Non-routine problems can be applied in everyday life to develop problem-solving, and mathematical thinking in students and make students have high tech [13]. Teachers providing non-routine problems can increase students' confidence in solving mathematical problems correctly and adequately. The provision of non-routine problems is certainly not spared from a teacher who gets used to it [14]. The habituation of teachers in giving students non-routine problems are problems that students do not immediately find the answer to. This will make students not confused when next getting a problem that requires solving mathematical problems [15-17].

5. Conclusion

Polya steps in solving mathematical problems can be done in 4 stages: understanding the problem, devising a plan, carrying out the plan, and looking back. We suggest to educators and advanced researchers to train students to solve mathematical problems, especially the stages developed by Polya to improve and train student intelligence in the mathematical learning process. Students who can solve mathematical problems with Polya steps can be the beginning of learning mathematics. Once students can understand the mathematical concepts learned. It can make it easier for students to learn problems in other mathematics, mathematical problems Solving through Polya steps makes it easier for students to learn the skills in other mathematics such as mathematical communication, mathematical reasoning, mathematical representation, critical thinking, and mathematical creativity. Mathematical problem-solving skills with Polya measures are a demand for all schools to train students' mathematical literacy.

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