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A test construction based on mathematical problem solving ability for quadrilateral

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Abstract. The ability to solve mathematical problems becomes an important skill the students should possess. Thus, it becomes an important duty for the teachers to help the students solve any encountered problem in their daily life. In the classroom learning, they need to teach the students how to solve the problem. It is not enough by assigning the routinized problems. This research aimed to construct a mathematical problem-solving test to assess students mathematical problem-solving ability. The research method included several steps, namely: analysis, developing test, evaluating test, trial, revising the test and collecting data on test validity and reliability. The research data were collected by using a written test, which was administered to 31 seventh-grade students at one of state Junior High Schools. The test consists of four essay questions with four indicators. The results showed that: (1) the mathematical problem-solving test was considered valid and applicable; (2) the test showed a good distinguishing power; and (3) the difficulty levels of the instrument were moderate and difficult. In conclusion, the constructed mathematical problem-solving instrument is applicable to assess the students mathematical problem-solving ability.

1. Introduction

Mathematics is one of the sciences used in everyday life. Almost all aspects of human's life involve mathematics. Mathematics needs to be taught because it is needed and useful in solving the everyday-life problems [1]. Its use is one of the reasons why it needs to be taught at schools. Geometry is one of the oldest and most basic branches of mathematics [2]. Geometry is heavily involved in everyday life. One of which is included in materials about quadrilateral.

Problem solving is an important and must-have ability for students. This skill becomes the essence of mathematics [3]. The importance of this skill according to the National Council of Teacher Mathematics [4] is regarded as part of the higher-order thinking aspects that allows the students to develop their intellectual aspect. The intellectual aspect in this case includes: (1) able to formulate and investigate the problem; (2) able to collect and analyze the problems from mathematical lens; (3) able to find the right strategy; (4) able to use the learned knowledge and develop mathematical ability; (5) able to reflect and capture the process of mathematical thinking. Learning geometry at schools opens more opportunities for the students to explore, observe, and discover every learning process, especially in doing the tasks related to problems about geometry. The problem-based tasks require a variety of



strategies to be employed, so that it will train their thinking skills. The problem-solving activities in geometry are good for the development of their thinking related to space, constructive, and real-world matters.

In developing the problem-solving skills, the students need to be equipped with non-routine questions. Therefore, the mathematics learning activity is needed that can involve them to think. One of them is by constructing a mathematical problem-solving instrument for rectangular materials for grade VII students. The purpose of this research was to construct a mathematical-problem solving instrument to measure their ability in solving mathematical problems related to rectangular learning materials.

2. Experimental method

This research constructed a mathematical problem-solving instrument to assess the students ability in solving mathematical problems. The research method included several stages, namely: analysis, developing test, evaluating test, trial, revising the test and collecting data on test validity and reliability[5]. The researchers constructed four mathematical problem-solving instruments related to quadrilateral learning materials. Furthermore, this mathematical problem-solving instrument was theoretically validated by two Mathematics lecturers whose educational background is in Mathematics education major and a Mathematics teacher who has similar educational background to the lecturers. The instrument was tested on 31 seventh-grade students in one of the state Junior High Schools.

3. Results and discussion

3.1. Analysis

Researchers analyzed some journals and books related to mathematical problem solving to construct the test on problem-solving ability. The results of the analysis were based on the operational indicators and definitions of problem solving. Therefore, it is very important for teachers to develop mathematical problem-solving instrument to assess the students problem-solving abilities about quadrilateral learning materials.

3.2. Developing test

The next step was to develop a mathematical problem-solving instrument. The researcher constructed the instrument for quadrilateral learning materials. There are four essay questions about solving mathematical problems. The indicators used were based on those mentioned by NCTM. They include: building new mathematical knowledge through problem solving, solving problems that arise in and outside the mathematical context, implementing appropriate strategies to solve the problems, observing and reflecting on the mathematical problem-solving process. This study employed a scoring guideline that refers to the NCTM scoring criteria [6]. The used indicators are depicted in Table 1.

Table 1. Indicators of mathematical problem-solving ability.

Question	Indicator	Score
1	Building new mathematical knowledge through problem solving	4
2	Solving problems that arise in and outside the mathematical context	4
3	Implementing appropriate strategies to solve the problems	4
4	Observing and reflecting on the mathematical problem-solving process	4

3.3. Evaluating Test

Test is validated by three experts. Two experts are lecturer of mathematics education who have a mathematics education background and one expert is a mathematics teacher who also has mathematics education background. Validity tested consists of content, construct and size validity.

3.4. Trial and revising the test

In this steps, mathematics problem solving test are tested to 31 students of junior high school. There are 18 female students and 13 male students as sample. The researchers tested in the class VIII students because they had already learned about quadrilateral. The test is done individually for 80 minutes. Based on advice from validation experts, tests are revised by changing the words, changing questions and adding pictures.

3.5. Collecting data on test validity and reliability

The next step was to assess the answers that had been tested on the students previously. There are four instrument criteria that must be met related to the mathematical problems that will be evaluated. The first was the validity test. Validity indicates the level of validity of an instrument. The validity tests were analyzed using product moment correlation technique. The second was the reliability test. An instrument is said to be reliable if the evaluation results are relatively consistent. The reliability of the mathematical problem-solving instrument was obtained by Alpha Cronbach.

The third was discrimination power test. The test was conducted by using the following computation formula [7].

$$DP = \frac{JB_A - JB_B}{JS_A}$$

Information:

DP : discrimination power

JB_A : the number of correct numbers among the high-level group

JB_B : the number of correct numbers among the low-level group

JS_A : the ideal score for the high-level group

The interpretation of the discrimination power of the mathematical problem-solving instrument indicated good, good, good, and enough (each category for each question). The last test was the difficulty level test. This test was calculated by using the following formula [8].

$$TK = \frac{JB_A + JB_B}{JS_A}$$

Information:

TK : difficulty level

JB_A : the number of correct numbers among the high-level group

JB_B : the number of correct numbers among the low-level group

JS_A : the ideal score for the high-level group

The results of the difficulty level test on the mathematical problem-solving instrument indicated moderate, difficult, medium, and difficult (each category for each question).

The recapitulation of the results from validity test, reliability test, discrimination power test, and difficulty level test on the mathematical problem-solving instrument is depicted in Table 2.

Table 2. The recapitulation of the results test.

Item	Validity r_{xy}	Validity Criteria	Reliability	Distinguishing DP	Distinguishing Criteria	Difficulty Levels TK	Difficulty Levels Criteria	Decision
1	0.69	High	0.62 Moderate criteria	0.41	Good	0.39	Moderate	Used
2	0.89	Very High		0.50	Good	0.28	Difficult	Used
3	0.63	High		0.41	Good	0.39	Moderate	Used
4	0.61	High		0.31	Adequate	0.15	Difficult	Used

Table 2 shows that, all mathematical problem-solving test can be used to assess students' mathematical problem-solving abilities based on all four tests. In the validity test, 1, 3, and 4 can measure test exactly whereas test 2, can measure well. The reliability test indicates that the test has a moderate consistency to measure the ability to solve mathematical problems. Differential power test show that tests can differentiate students with high ability and low ability. The difficulty level test has a moderate and difficulty level.

4. Conclusion

Based on the analysis and results of the trials described earlier, the researcher draw three conclusive points. First, the mathematical problem-solving instrument was considered to be appropriate for assessing students mathematical problem-solving abilities. In other words, the instrument was theoretically valid for assessing the students ability to solve mathematical problems about rectangular. Second, the instrument showed a good distinguishing power. This indicated that the instrument can differentiate students answers between those who understand and those who do not understand about quadrilateral learning materials. Third, the difficulty levels of the instrument were moderate and difficult. It means that the instrument still have varying levels of difficulty.

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