Measurement of mathematics problems solving ability using problem based mathematics question

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Measurement of mathematics problems solving ability using problem based mathematics question

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Abstract. The purpose of this study is to produce the valid, practical, and effective problem-based questions to measure the mathematical problem-solving abilities of eighth-grade students of junior high school. The materials used as the basis of development are system of linear equation in two variables and the Pythagorean theorem. The development model used is the Plomp model consisting of three stages; preliminary research, prototyping phase, and Assessment phase. Based on the results of these stages, 16 problem-based questions were obtained which are valid to the criteria of content, constructs and determined language, practically used by the teacher, and effective for measuring students' mathematical problem solving abilities because they can direct students to identify problems, plan solutions, implement solutions, and need to carry out evaluations as indicators of problem-solving abilities.

1. Introduction

Mathematics as a basic science plays very important role in the development of science and technology. Mathematics is a mean of thinking to develop the power of reason as wells as logical, systematic and critical way of thinking[1]. It is also in line with National Education Minister that the ability of Mathematical Problem Solving must be acquired by the students[2] Students need to have problem-solving ability, through this abilitiy students can show their potential to solve problems around them. Mayer stated that problem-solving is a cognitive process directed towards achieving goals when there is no clear solution method for problem solvers [3]. It needs to be developed on students in order to avoid being desperate in facing a problem. The problem-solving ability can be obtained through several ways, one of them is by learning mathematical material and solving problem-based questions. Vayor stated that on mathematics learning at school, problem-solving skill in K-13 is a competency to develop students' mathematics ability[4]. But according to Demitra, the difficulty of solving problems in mathematics still occur in school [4]. Reality also shows that the problem solving ability of mathematics owned by learners in Indonesia at this time each classified as low[5]. It is necessary to find a solution so that students no longer have trouble in implementing mathematical problem-solving. One of the ways is to complete learning devices that can facilitate students to gain experiences in problem-solving and provide evaluation tools that can measure the level of mathematical problem-solving abilities of students.

Problem-based questions need to be developed in order to provide opportunities for students to hone their problem-solving skills. Problem-based Questions are type of the questions with three common criteria, such as open-ended, contextual, and non-routine. Open-ended problem are questions

that have more than one solution, or more than one answer. This means that open-ended problems are questions with an open category[6]. According Zulkardi and Ilma (2006), Sumarmo (2010), and Sumardyono (2011), the development of problems with open type and contextual nature of non routine can be used as means of improving the quality of the learning process, especially to improve problem solving skills and also mean of asssemen in mathematics[7]. The adminsitration of these questions provide a chance for the students to think actively and creatively. Problems are useful for training one's thinking skills. One of the subjects that cannot be separated from problems was mathematics[8]. Problem-solving ability is one of the standard processes in mathematics learning[9] Students can improve their problem-solving skills specifically on mathematics problems. The statement was also strengthened by , which states that the development of the questions that focus on problem solving abilities need to perceived as media in mathematics evaluation and learning process[7].

2. Experimental Method

The research model used in this study is the Plomp which consists of three stages, *preliminary research, prototype phase, and assessment stage* [10]. At the stage of the preliminary study, analysis of curriculum or material and needs analysis were carried out. At the stage of prototype development, self-evaluations, expert reviews, one-to-one, small groups, and field tests were conducted[10]. Furthermore, at the assessment phase, a test with four indicators is made regarding to mathematical problem-solving abilities of students. The subjects of the study were eighth-grade students of SMPN Bangkinang Kota. The developed mathematical question is the material of linear system of two equations with two variables which is studied at eight grades in Semester 1 and the Pythagorean theorem which is studied at the same grade but in the following semester.

3. Result and Discussion

3.1. Preliminary Research

Curriculum Analysis

The curriculum analysed in this study was the 2013. The problem based mathematical questions developed referred to the system of linear equations with two-variable and the Pythagorean theorem materials. The footage of the basic competencies and material indicators of the two-variable linear equation system and the Pythagorean theorem are as follows.

Table 1. Basic competencies and indicators in the material of two-variable linear equation system

Basic Competency	Indicators
3.5 Explaining the system of two variable linear equations and its solution related to contextual problems	3.5.1 Create two variable linear equations 3.5.2 Determine the completion of two variable linear equations 3.5.3 Make a mathematical model of everyday problems related to a two-variable system of linear equations
4.5 Solve problems related to systems of two-variable linear equations	4.5.1 Completing

Table 2. Basic competencies and indicators on the pythagorean theorem material

Kompetensi Dasar	**Indikator**
3.6 Explain and prove the Pythagorean theorem and triple Pythagoras	3.5.1 Check the correctness of the Pythagorean theorem 3.5.2 Determine the side of a right triangle if the length of two sides is known 3.5.3 Determine the type of triangle based on the length of the known sides 3.5.4 Find and test three numbers whether including triple Pythagoras or not triple Pythagoras
4.6 Resolve problems related to Pythagorean theorem dan Pythagorean triple	4.5.1 Applying the Pythagorean theorem to solve real problems

In Table 1 and Table 2, it can be seen that basic competencies are also developed so that students are able to solve problems related to the system of linear equations with two variables, and problems related to Pythagorean theorems and Pythagorean triple. Therefore, it is necessary to provide various problem-based questions to ease the teachers to obtain problem-based questions or as an evaluation tool.

Needs Analysis

Based on the results of interviews on six mathematics teachers in several schools in Pekanbaru, it was obtained information that the teacher needed problem-based questions. The questions can be used by the teacher to give variations on the questions in the system of linear equations with two variables, and the Pythagorean theorem materials. Numerous studies conducted by researchers in the field of mathematics education also require questions that can help measure problem-solving abilities. For example, the research conducted by Handayani related to the Effect of Missouri Mathematics Project Learning Model on Student's Mathematical Problem Solving. In the fifth stage of the Missouri project learning model, students will be given homework as a routine exercise conducted[11]. At this stage, the developed problem-based questions can be used by researchers.

3.2. Prototyping Phase

In the prototype phase, the questions that the researcher has developed will go through several stages. The questions developed are questions that are modified from various mathematical books. Problem-based questions were developed in 16 questions which refer to the two-variable linear equation system and the Pythagorean theorem materials.

Expert Review

At the expert review stage, the researcher will describe the results of the analysis or review that has been carried out by experts in mathematics, language, and educational technology education. Some of the results of the problem-based problem validation stage by the expert also refer to the Zulfah article under the title “Pengembangan Lembar Kerja Peserta Didik Berbasis Problem Based Learning untuk Materi Matematika Semester 1 Kelas VIII SMP Pada Tahap Preliminary Research”[12]. The validity aspects used in the development of problem-based questions are as follows.

Table 3. Validity aspects of the question

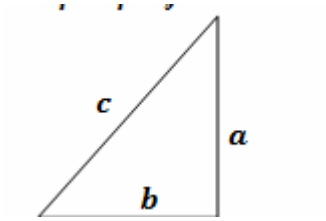
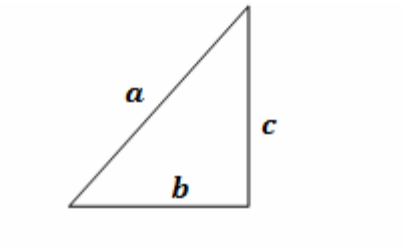
Assessed Aspects	
Evaluation Components	**Indicators**
Content	1. The developed questions have various answer or various way of answering (*open-ended*) 2. The Questions are contextual 3. The developed questions are not routine. 4. The developed questions refer to indicators. 5. The Content of material asked is fit to type and level of school, VIII SMP.
Construct	1. The picture used are clear. 2. There is a clear instruction for working on the questions.
Language	1. The question items use adapted EYD sentence. 2. The sentence of the question fits to the knowledge level of students. 3. Disuse of ambiguous expression causing multiple interpretation.

Based on the result of expert validity it was obtained suggestion dan revision as follows:

Table 4. result of expert review on spldv material

No	Recommendation for Improvement	After Revision
Didactic aspects		
1	Fix the problem **Statement 1** A factory produces two kinds of bottles, namely Bottle A and Bottle B. The total Productions are 200 bottles. Bottle A is distributed by Rp.3000/bottle, while B is distributed by Rp. 5.000.bottle. After distributing to the market area, the total of selling price is Rp.708.000	**Statement 1** To produce a cake, mom buys chocolate bars.The amounts are 1500gr. The chocholate are distributed in the bakery then. There are two available packages., 100 gr in Rp.12.500, and 150 gr in Rp.18.500. The bakery provides discount 500 for every buying of 1oo gr package.
Content Aspect		
2	The difficulty level of the question needs to be adjusted to the students' ability.	On the problem, it is started by giving students' daily life problem for example problem when Mother wants to buy chocolate.
Language Aspect		
2	Fixing the dubious statements	Improvement is conducted to dubious statements.
3	Fixing the choice of word	Repairing is conducted to the choice of word.

Tabel 5. the result of expert review on pythagorean theorem material

No	Recommendation for Improvement	After Revision
Language Aspect		
	Fix the term, symbol and structure used. When the placement of the letter symbol on a triangle is anti-clockwise, you need to be consistent on it.	
2		

One-to-one

Prototype 2 was obtained after the revised results of prototype 1. Prototype 2 was used in a one-to-one test. One-to-one tests are conducted on 3 eight-grade students of SMPN Bangkinang Kota. The three students have different abilities ranging from high ability to low ability. Based on the results of the one-to-one analysis, it was found that students had difficulty in solving problems because questions were too long. Based on the results of the one-to-one test, a prototype 2 revision was carried out. The revised results on prototype 2 produced prototype 3. Next, this prototype will be tested to the small group stage.

Small Group

Prototype 3 was then tested in the small group stage. This stage involved 6 students with high, medium and low abilities. It was conducted so that the questions developed later can be understood by various characteristics of students. The footage of the results of the small group stage trial as follows. Based on the results of the small group trial, a revision was then carried out, and prototype 4 was obtained. Prototype 4 was a problem-based question that was valid and practical after going through various stages.

Field Test

At the stage of the Field test, the valid and practical prototype 4 was used to evaluate the effectiveness of problem-based questions developed on students' mathematics problem-solving abilities. Indicators of problem-solving abilities used in this study are (1) Able to identify problems, (2) able to plan the problem-solving strategies, (3) able to implement the problem-solving plans, and (4) able to evaluate solutions given. The field test included 23 students.

Problems Based on Valid and Practical Problem Solving

Based on the results of the expert review and one-to-one test, the valid problem-based questions were obtained. The developed problem-based question consists of 16 questions with reference to the two-variable linear equation system material and the Pythagorean theorem. Valid problem-based questions have criteria that are based on the content of the questions developed must be open-ended which answers given by students have the possibility of different answers or different ways of answering. The developed questions must be contextual, or non-routine. Non-routine questions mean not only

using one formula but can be more or answer informally. The contents of the material asked were also in accordance with the type of school or school level, eight-grade students of SMP. The question developed is in accordance with the indicators of the material system of two-variable linear equations and the Pythagorean theorem. In the construct section, clear images are used, and there is a clear instruction for working on the questions. In the language aspect, the question sentence is adapted to EYD and is adjusted to the level of knowledge of the students. The practicality of problem-based question with the criteria that problem-based questions can be used by the teacher in providing diverse questions.

Problems Based on Effective Problem Solving

The problem-based questions developed are said to be effective because they can be used to evaluate students' mathematical problem-solving abilities because the answers given by students are in accordance with the indicators of mathematical problem-solving abilities. The problem-based questions developed as many as 16 questions which questions can also measure the problem solving ability, includes the skills of identidyng and understanding the problem. Planning ways to solve a problem, monitoring progress as the problem is tackled and then reviewing a solution to a problem[7]. The several questions that are produced are as follows Figure 1 and Figure 2.

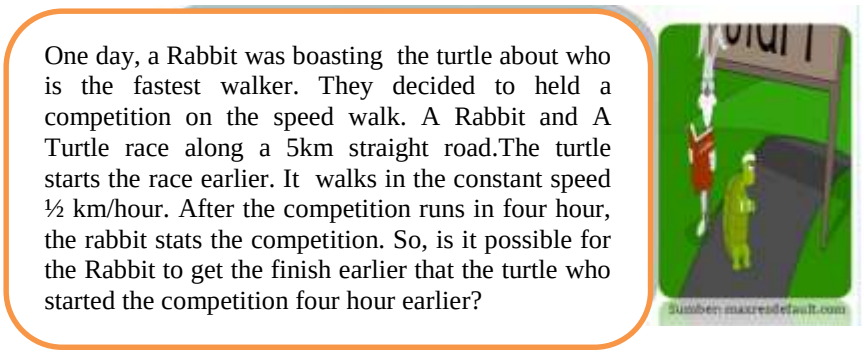


Figure 1. Footage of problem based questions developed for SPLDV materials

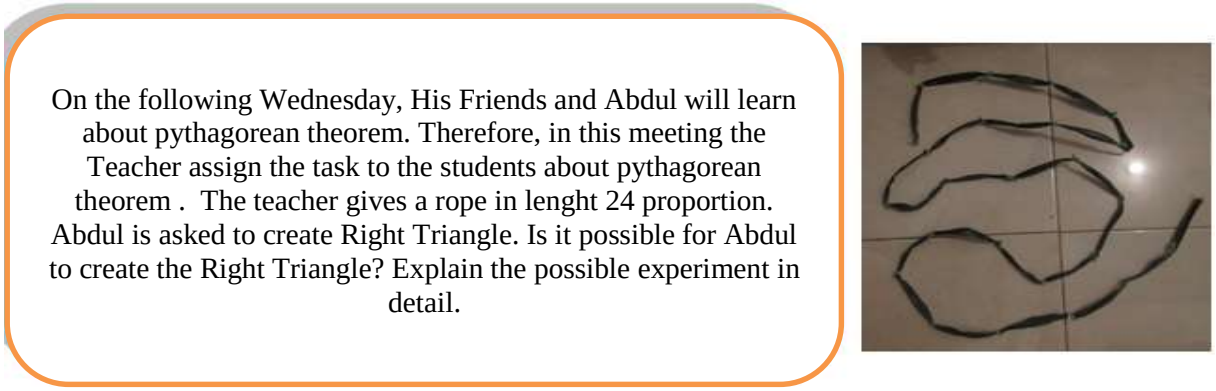


Figure 2. Footage of problem based questions for the Pythagorean Theorem material

4. Coclusion

Based on the development results of problem-based question were obtained 16 valid, practical, and effective questions for system linear equation with two-variable material and the Pythagoras theorem. Problem-based question validity was obtained through Expert Review stages and one-to-one trials. Experts in this matter are experts in the fields of mathematics education, language, and in the field of educational technology. Each expert consists of two people. These problem-based questions are said to be valid with predetermined criteria which are in accordance with the content, constructs, and

language. The questions developed are open-ended, contextual, and non-routine, the problem refers to the two-variable linear equation system material indicators and the Pythagorean theorem. The problem-based questions developed have clear images and clear instructions. Problem-based questions have Standard Indonesian Spelling System or EYD sentences and are easy for students to understand. The results of the problem-based prototyping phase conducted at SMPN Bangkinang Kota have similarities to the results of the development that the researcher did before at SMPN 13 Padang.

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