Development of learning device oriented problem based learning to improve student’s mathematical problem solving skill

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Abstract. This research study is research and development learning devices. The purpose of this study were: 1) Developed problem based learning tools with criteria are valid, practical, and effective; 2) Described the improvement of mathematical problem solving skills of student using learning device based on problem based learning developed. Learning device development using 4-D model which developed by Thiagarajan, Semmel and Semmel, was done in two stages: 1) the development of learning devices; and 2) testing devices. The subject in this study were students of class X SMAN 1 Pematangsiantar, while the objects is the PBL developed, mathematical problem solving skill students. The results were obtained: 1) The learning devices based on PBL that developed have valid criteria, practical and effective; 2) There is an increased ability of mathematical problem solving skill of student using learning device based PBL developed.

1. Introduction

Improving the quality of education in an era of development that is constantly changing significantly, is felt as a need of a nation that wants to advance, with the belief that quality education can support development in all fields. So, education is the only right tool to build high-quality human resources so that it can advance this country. The quality of education is closely related to learning held in schools. Learning is one of the most important elements in the implementation of education. The quality of education is determined by various dominant factors including; teachers, school principals leadership, school facilities and infrastructure including the completeness of books, media / learning tools, school libraries, without exception the curriculum that suits the needs of students [1]. From the opinions above, one of the most important components in the quality of education is a learning tool. The quality of the learning tools used also determines the quality of learning. According to Subanindo, Learning tools are a collection of learning resources arranged in such a way that students and teachers do learning activities [2]. Learning tools are an important part of the learning process.

Government Regulation No. 19/2005 relating to national education standards suggests that teachers are expected to develop learning plans, which are then confirmed through Minister of Education Regulation No. 41/2007 concerning process standards [3]. To meet these process standards, learning must be planned, assessed and monitored. One of the learning plans is to arrange learning tools. The
learning tools are in the form of Learning Implementation Plan (RPP), Teacher's book (BG), Student's Book (BS), Student Activity Sheet (LAS), evaluation instrument or learning ability test (TKB) as well as learning media. The importance of learning tools in teaching and learning activities so that development is highly demanded by every teacher and prospective teacher.

According to the results of observations to several schools obtained information that the learning tools used by teachers in schools are still focused on the material contained in the curriculum, so students tend to only memorize mathematical concepts without understanding their intentions and contents. In this case the development of learning tools is needed to support the achievement of expected learning objectives. Problem-solving ability is also one of the standard processes in learning mathematics as formulated by the National Council of Teachers of Mathematics [4]: Outlining students must learn mathematics through understanding and actively build on their prior knowledge. To realize this, mathematics learning is formulated in five general objectives, namely: first, learning to communicate; second, learn to reason; third, learning to solve problems; fourth, learn to associate ideas; and fifth, the formation of a positive attitude towards mathematics.

The ability to solve problems makes students able to solve mathematical problems related to routine problems, non-routine problems to the application of mathematics in everyday life. Sovhick states that the practice of problem solving will produce individuals who are competent in the field of mathematics because it has great benefits on the inculcation of students' mathematical competence [5]. But the reality on the ground, the mathematics learning process carried out at this time does not meet the expectations of the teachers as developers of learning strategies in the classroom. Students have difficulty in learning mathematics, especially in solving problems related to mathematical problem solving abilities.

The low problem-solving ability can also be seen from the results of initial observations and interviews with mathematics teachers at SMA Negeri 1 Pematangsiantar that students experience difficulties in problem solving, the teacher reveals that students are not accustomed to writing down what is known and asked in questions, even most students do not understand the questions and don't know how to solve it.

Based on the first indicator of problem solving ability, namely understanding the problem, there are 5 students (22.85%) who are able to write what is known and asked in the problem; planning problem solving, there are 10 people (28.57%) who are able to plan problem solving using the concept of a system of linear equations; in solving problems according to plan, there were 9 people (25.71%) people were able to solve correctly according to plan and on checking back the results of problem solving there were 6 students (17.14%). Thus, based on the four indicators of problem solving it is concluded that the students' problem solving ability is still low.

Responding to problems that arise in mathematics learning as described above, especially related to the problem solving ability and mathematical positioning of students, it is necessary for the teacher or researcher to choose learning that can change the paradigm. The Problem Based Learning Model (PBM) is one solution. This model is a learning approach for students on authentic (real) problems so that students can compile their own knowledge, develop high skills and inquiry, independent students, and increase their confidence [6]. By using a problem based learning model, students deal with problems and try to solve them with the information they already have allowing them to appreciate what they already know. They also identify what they need to learn to better understand the problem and how to overcome it.

Learning with the problem based learning model is one of the learning that is centered on students and teachers as facilitators. Problem-based learning is learning that uses real-world problems as a context for students to improve their problem solving skills and mathematical disposition and to obtain essential knowledge and concepts from the subject matter. Contextual problems that are given aim to motivate students, arouse student enthusiasm for learning, increase student learning activities, focused learning on problem solving so students are interested in learning, find concepts that are appropriate to the subject matter, and with different interactions.
2. Methods
Based on the formulation of the problem and the stated research objectives, this research is included as a Developmental Research. The development model of the Thiagarajan, Semmel and Semmel learning models, the modified 4-D model (define, design, develop, disseminate). This developmental research was carried out to produce the necessary learning tools and instruments which would then be tested in class. The learning device developed was a mathematics learning device for high school level linear equations system using problem based learning. The development of learning tools is in the form of designing learning tools starting from the Learning Implementation Plan (RPP), Student Books, Teacher's Books, Student Activity Sheets (LAS), Learning Outcomes Test (THB).

The research instrument consisted of: a learning device validation sheet, an observation sheet for the implementation of the learning device, a student response questionnaire, and a student mathematical problem-solving ability test sheet.

2.1. Research subjects and objects
The subjects in this study were students of class X SMA Negeri 1 Pematangsiantar in the 2016/2017 school year and the class chosen by random sampling was class X PIA 6 in trial I and X PIA 1 in trial II, while the object of this study was the learning device problem based on the material developed linear Equation System (SPL) are Teacher's Book (BG), Student's Book (BS), Learning Implementation Plan (RPP), Student Activity Sheet (LAS), Problem Solving Ability Test (TKPM).

2.2. Field trial design
The design of the trials used in the development of learning devices is to carry out field trials. If in the first field trial, the learning device has not been categorized as practical and effective, then a revision of the device will be conducted, which will then be conducted in the second field trial until the learning device is said to be practical and effective.

2.3. Development of research instruments

2.3.1. The validity of learning devices. Learning devices are said to be valid if they meet the criteria of content validity and construct validity. The validity of content was done by 5 validators by giving score 1 to 5 in each assessment column based on aspects: 1) format, 2) language, 3) content, and 4) illustrations. Furthermore, the overall expert assessment was processed by calculating the average score to obtain the criteria of content validity assessment and will be outlined in Table 1.

| Average Validity (Va) | Criterion Validity |
|----------------------|--------------------|
| 1 ≤ Va < 2           | Invalid            |
| 2 ≤ Va < 3           | Less valid         |
| 3 ≤ Va < 4           | Enough Valid       |
| 4 ≤ Va < 5           | Valid              |
| Va = 5               | Best Valid         |

2.3.2. The practicality of learning devices. The learning devices implementation was observed based on the observer’s assessment where they chose score 1 to 5 on each aspect of learning devices implementation that were lesson plans, handbook’s teacher, student’s book, and worksheets. The average total score obtained was categorized into the percentage of learning implementation. Criteria improvement learning devices is as follows:

- Very Low, If \( 0 \leq \bar{P} < 1 \)
- Low, If \( 1 \leq \bar{P} < 2 \)
- Enough, If \( 2 \leq \bar{P} < 3 \)
High, If \(3 \leq \bar{P} < 4\)

Very High, If \(4 \leq \bar{P} < 5\)

Annotation: \(\bar{P}\) is the average score

Learning device is said to be practical or easy to implement if the enforce ability of the learning devices are in the category of high minimal. As for the reliability of the observation sheet doing, learning device was tested with the following formula, Borch [7]:

\[
\text{Percentage of agreement} = \left[ 1 - \frac{A-B}{A+B} \right] \times 100\%
\]  

(1)

Annotation:
A: Frequency aspects of behaviour observed by observers give high frequency
B: Frequency aspects of behaviour observed by an observer who provides low frequency.

Observation sheet improvement learning devices is said to be good if it has a reliability coefficient of 75%.

2.3.3. The effectiveness of learning devices. The test is given at the initial meeting (before it is done at the end of the learning meeting (after all topics have been taught) and the students' mathematical problem-solving ability test instruments are developed in accordance with the learning indicators. The students' mathematical problem-solving abilities are arranged based on the student's mathematical problem-solving test grid. A student can be said to be complete if the individual student score reaches KKM \(\geq 75\). Furthermore, classically that a learning is considered complete, 85% of students who take the test have achieved KKM score \(\geq 75\) [6].

Student Activity Observation Sheet. This instrument is used to obtain data about student activities during the learning process using problem-based learning tools. Student response questionnaire Sheet this instrument is used to get data about student responses during the course of learning using problem-based learning tools.

3. Results and discussion

3.1. Validity

At this stage content validity and construct validity are performed. Content validity is done by 5 validators. Validation results by the validator indicate that all learning devices developed have met the valid criteria with a total average value of lesson plan validity of 4.6, handbook’s teacher of 4.7, student books 4.6, and worksheet validity 4.6, test of problem solving ability has been in valid category and reliability score is 0.807 (very high category).

3.2. Practical result of learning device

In the implementation of field trials producing data on the quality of learning tools in the form of practicality of learning devices, can be seen in the following table 2.

| Practicality of learning devices | Mean scores of trial I | Mean scores of trial II | Category |
|---------------------------------|------------------------|-------------------------|----------|
| The implementation of learning devices | 4,10                   | 4,30                    | High     |
| Instrument reliability learning devices | 98,53%                 | 98,2%                   | Good     |

3.3. The effectiveness of learning tools

3.3.1. Completeness results Students' mathematical problem solving abilities. The results of field trials to see students' mathematical problem solving abilities can be seen in the following table 3.
Table 3. Completeness level of students mathematical problem solving ability in field trials.

| Category         | Trial I Number of Students | Completion Percentage | Trial II Number of Students | Completion Percentage |
|------------------|----------------------------|-----------------------|----------------------------|-----------------------|
| Completed        | 19                         | 54.28%                | 26                         | 86.67%                |
| Not Completed    | 16                         | 45.72%                | 4                          | 13.33%                |
| Amount           | 35                         | 100%                  | 30                         | 100%                  |
| Class Average    | 75.26                      |                       | 82.87                      |                       |

3.3.2. Results of student learning activities during learning. The results of field trials to see student learning activities during learning can be seen in the following table 4.

Table 4. Total results of student activities in learning in group 1 field trials.

| Activity                                           | Average Percent | Criteria Limitation |
|----------------------------------------------------|------------------|---------------------|
| Pay active attention / listen to teacher / friend explanation | 11.20            | 9%-19%              |
| Read, understand contextual problems in Student Activity Sheets | 13.02            | 6%-16%              |
| Solve problems / find answers and how to answer problems | 38.28            | 33%-43%             |
| Discuss / ask questions between students and teachers | 22.40            | 19%-29%             |
| Draw conclusions for a procedure or concept         | 13.28            | 8%-18%              |
| Student behavior that is not relevant to KBM        | 1.82             | 0%-5%               |

Amount 100

3.4. Improvement of students mathematical problem solving ability

Improving students' mathematical problem solving abilities by using learning tools that apply a problem based approach from the Post-test results can be seen in the following table 5.

Table 5. Improved average students' problem solving ability for each indicator.

| Problem solving capability indicator | Average | Improvement |
|-------------------------------------|---------|-------------|
|                                     | Trial I | Trial II    |             |
| Understanding problems              | 2.32    | 2.57        | 0.25        |
| Planning for completion             | 2.41    | 2.52        | 0.11        |
| Resolving problem                   | 2.16    | 2.39        | 0.23        |
| Checking                            | 0.63    | 0.79        | 0.16        |
| Total of average                    | 7.52    | 8.27        | 0.75        |

3.5. Discussion

The instrument used in this study consisted of an instrument of the validity of a learning device, a practical instrument of a learning device, and an instrument of the effectiveness of a learning device. These three instruments are arranged by themselves with reference to theories related to the validity, practicality and effectiveness of learning tools. Before being used in field trials, all three instruments had gone through the instrument validation process involving five experts.

The results of the validation of the learning instrument validity instruments in the form of Learning Implementation Plan (RPP), Student Books, Teacher's Books, Learning Outcomes Tests in the Reasoning Ability Test, Learning Tools Implementation Validation Sheet, Teacher Response...
Questionnaire Validation Sheet, Student Response Questionnaire Validation Sheet, Student Activity Validation Sheet Students and Teacher Ability Validation Sheets Using Learning show all these instruments are valid.

Obtaining a valid learning tool, caused by several factors, including: (1) The components of the learning device with a problem-based approach developed are in accordance with the indicators set in the instrument of validity of the learning device. The refinement is based on revisions and suggestions from the validators to improve the learning tools with the characteristics of a problem-based approach; (2) Learning tools developed in accordance with the aspects of measurement of content validity and construct validity expressed by Nieveen. The learning device fulfill the validity of the content, meaning that its development has been based on theories that are used as guidelines in the formulation or preparation of the learning device. While the learning device has met the construct validity, it means that in its development, it has paid attention to the interrelationship between the components in the learning device. Learning with PBM starts from something real so students can be involved in the learning process meaningfully. In learning mathematics, students can develop knowledge and understanding of mathematics if given space and opportunities. Students can reconstruct findings in the field of mathematics through activities and exploration of various problems, both problems in everyday life; (3) In its development, learning tools have been arranged in accordance with curriculum demands found in junior high schools. The demands of the curriculum relate to competency standards and basic competencies that must be achieved in mathematics learning activities, so that they can be used properly in learning.

Furthermore, for the practicality of the learning device, it can be said that the practicality of the learning device that was developed is easy and can be implemented because it meets the specified practicality indicators, namely the results of the value sheet of the implementation of the learning device, student response, and response The teacher has fulfilled the practicality criteria. The implementation of learning tools based on field trials obtained a score of 4.1 at class trial II and 4.3 at class trial II in the practical category.

Based on the description above it can be said that the learning tools using a problem based approach have fulfilled the practicality of the devices as expected. This means that learning tools that are successfully developed are easy and can be implemented by teachers and students. As for some things that support practicality are: (1) lesson plan arranged easily understood and easy to use by teachers in the learning process, learning steps based on a problem-based approach, easily implemented by teachers in the implementation of the learning process (2) Student Activity sheet that is arranged is easy to understand by students because the instructions given are clear, the writing is easy to read, the pictures and tables used are easy to understand so that it will make it easier for students to use it, (3) Student books are arranged with sentences that are easy to understand, materials arranged systematically and (4) Books The teacher arranged can be a teacher's guide in carrying out teaching and learning activities. This is in line general criteria for learning resources one of which is practical and simple [8]. The point is that learning resources that are used should not require services or procurement that are difficult and rare.

Effective indicator is the ability of teachers to use learning, obtained a score of 4.08 in the "good" category (3.50 - 4.49). The effectiveness criteria of the devices are in the "good" category, so the teacher's ability to use learning is already effective. The first and second observers give an assessment both at the preliminary stage, the core and closing activities. This is in line with what Freudenthal suggests, in problem-based learning the role of the teacher is no more than a facilitator, moderator or evaluator while students think, communicate reasoning, practice the nuances of democracy by respecting the opinions of others [9].

The last indicator of effectiveness is student activity, obtained for each meeting of student activities that are within the criteria for limiting the effectiveness of learning, for student activities included in the effective category. Learning activities are all things that are deliberately designed by the teacher to facilitate student learning activities such as discussions, demonstrations, conducting experiments and so on [10]. From all the results obtained in the field trials it was concluded that the learning device was
effective because classical learning completeness met the completeness criteria is 85% of the total number of students, so a Final Draft was obtained that was a learning device that was suitable for use.

4. Conclusion
Based on the results of the analysis and discussion in this study, the following conclusions are presented:

- Validity Problem-based learning tools developed include valid categories, with an average rating from the experts obtained: (1) Learning Device Plans (RPP) of 4.6; (2) Teacher's Book (BG) of 4.7; (3) Student Books (BS) of 4.6; (4) Student Activity Sheet (LAS) of 4.6; as well as the results of limited trials obtained (5) Problem Solving Ability Test (TKPM) said to be valid for each item with a reliability value of 0.807 (very high).
- Problem-based learning tools developed include practical categories with expert judgments found that: (1) devices can be used with little revision and observations; (2) the results of observations of the feasibility of learning devices in the classroom obtained an average value that is in experiment I of 4.10 (very high / practical) and in experiment II of 4.3 (very high / practical) and (3) instrument reliability in class experiment I was 98.53 (good) and in class experiment II it was 98.20 (good).
- Problem-based learning tools developed respectively included in the effective category with indicators: (1) the classical completeness of students in experiment I was 54.28% and in experiment II it was 86.66%; (2) Achieving the percentage of ideal time for student activity is in achieving ideal time for student activity with a time tolerance of 5%; and (3) more than 80% of students responded positively to the learning tools developed.
- Students' problem-solving abilities using problem-based learning tools developed increased in terms of the average achievement of students' problem solving abilities, namely in Experiment I of 54.28%, increased in Experiment II of 86.66% and the average of each indicator of problem solving ability Student problems increased from experiment I by 7.52 to experiment II by 8.27.

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