Development Of Mathematical Learning Devices Based On Inquiry To Improve Mathematical Problem-Solving Skills Of Tenth Grade Students In Vocational School

Veggi Yokri, Dony Permana, Yerizon

Abstract: This development research aims to provide an inquiry-based mathematics learning tool for tenth-grade students of Vocational School that are valid, effective and practical in order to develop their mathematical problem-solving abilities. This research is motivated by the learning of mathematics in schools, especially in vocational high schools (SMK) that have not supported the development of problem-solving skills. The priliminary results of interviews and observations were taken in SMAKPA, West Sumatra. The resealed that teachers merely depended on questions in textbooks although a few of them gave questions in an effort to train mathematical problem-solving skills. The existing student worksheets (LKPD) were not prepared by the teacher itself but were purchased from the publisher and even did not use LKPD. The form of RPP and LKPD are used as tools developed in this study. Three stages of the development model of Plomp are applied. The research data was collected by interviews, questionnaires, observation sheets, and analysis sheets as well as tests of mathematical problem-solving abilities. Therefore, The results of the study showed that the mathematics learning tools produced meet valid, practical and effective categories both in terms of feasibility and validity. In other words, the developed device can be used as reference material in mathematics learning that is oriented to problem-solving skills in tenth-grade students in SMKPA.

Keywords: Inquiry, Scientific Approach, and Mathematical Problem Solving.

1. INTRODUCTION

One of the objectives of learning mathematics is to develop problem-solving abilities [1]. Mathematical problem-solving ability is the ability of students to use mathematics in their daily lives [2]. The ability to solve mathematical problems becomes the focus in mathematics learning in schools because the thinking skills and skills used in mathematical problem-solving processes can be transferred into various fields or life situations.

The experiences gained by students through this problem-solving process have implications for the development of the ability to understand the information that is spread around them. In other words, this ability enables increased other thinking skills such as the ability to think analytically, logically, systematically, critically and creatively.

The reality in the field shows that not yet fully learning mathematics in schools, especially in high schools (SMA / SMK) supports the development of problem-solving abilities. Mathematics learning is not maximized in the class [3]. The achievements of SMK students in mathematics learning are still relatively low, especially in terms of problem-solving skills [4]. Students given questions in the form of problem-solving problems are most difficult to work on the problem [5]. How problem-solving ability because students have thoughts that are only fixated on one step of the answer and when presented with another problem they will be confused [6].

The results of observations and interviews at one of the vocational high school in Padang found difficulties in answering problem-solving problems. Some students have not been able to understand the problem well, also some others

- *Veggi Yokri, Dony Permana, Yerizon*
- *Student of Postgraduate FMIPA, Universitas Negeri Padang* Veggi.iim0501@gmail.com
- *Lecturer Mathematics Education Department FMIPA, Universitas Negeri Padang* donypermana@gmail.com
- *Lecturer Mathematics Education Department FMIPA, Universitas Negeri Padang* Yerizon@fmipa.unp.ac.id

have not been able to do the work step systematically, the difficulty in the process of selecting strategies is the right problem and only able to answer using a problem-solving strategy (the questions provided can be solved with several resolution strategies problem).

The results of the question tests conducted at one of the Padang Vocational High School vocational high schools supported information about problems that occurred regarding this capability. Problems found include the answers of students in answering problem-solving questions like the following.

"First there are 4 bacteria, every 10 minutes the bacteria divide into two folds and every 30 minutes the bacteria die quarter of a part. How many bacteria live in the 100th minute? Declare your answer in the form of rank and find another strategy in solving the problem!

To answer the above questions students must understand the problem first, understand what information is obtained from the problem faced and examine what information is not available or not needed. After understanding the problem students are expected to develop a problem-solving strategy, either by looking for patterns, creating a table or diagram, making an equation or guess-checking strategy. Finally, students are expected to be able to conduct a re-examination process in the form of whether the results obtained make sense or are there other ways to solve the problem.

The results of the answers given by students showed that some students did not understand the problem very well. Students have not been able to do work steps systematically in understanding problems about what is known and what is needed in solving problems. The process of choosing a problem-solving strategy that is used is also not right and some students who are able to answer the question correctly are only able to use one problem-solving strategy. whereas, the above questions can be solved by several problem-solving strategies.

The problem-solving model is a process that explains what actually happened during the problem-solving process. The problem in this problem solving model is indicated by the inability of students to understand the problem, which includes understanding what is being done, what information is needed, available information and information that is not available that is useful for solving problems; planning problem solving, namely choosing the strategy needed to solve the problem; and re-examination of the original problem, which includes interpreting the answers to the original problem, examining whether the answers obtained make sense, and identifying whether there are other ways to solve the problem.

The approach to teaching mathematics at the Vocational School (SMK) in Padang needs to develop the capacity of students to solve contextual problems [7]. Teachers need to create an atmosphere that is interactive, inspiring, and fun and challenging learning [8]. There are many models or learning approaches that can be used in classroom learning. One of them is disclosure-based learning or research, namely Inquiry Learning. The inquiry is a series of learning activities that involve maximally all the abilities of students to search and investigate systematically, critically, logically, analytically, so that they can formulate their own findings confidently [9].the inquiry is a learning activity where students as individuals who actively seek knowledge by solving problems given by the teacher through investigations that involve interaction with the learning environment. Through inquiry learning students are expected to be able to find concepts and their own understanding of the topic or a problem so that it can improve the ability to solve problems.

The steps in the inquiry are as follows: (1) Presenting problems or statements, (2) making hypotheses, (3) designing experiments, (4) conducting experiments, (5) collecting and analyzing data and (6) making conclusions.

The main element that must be present in problem-solving and inquiry learning is a problem, namely a problem that encourages someone to solve it, but does not directly know how [10]. Problems can be presented directly in front of the class or in Student Worksheets (LKPD). Research on the development of mathematical learning tools based on actual inquiry has been carried out. These studies include [11,12,13,14,15,16,17]. The learning tools developed in this study are the Learning Implementation Plan (RPP) and inquiry-based Student Worksheet (LKPD) to improve student problem-solving skills.

2. Method

This type of research is development research which consists of three stages, namely preliminary analysis, development or prototyping phase, and assessment phase [18]. At the preliminary analysis phase, needs analysis, curriculum analysis, concept analysis and analysis of students to find deficiencies in the available learning devices are carried out. The preliminary analysis also aims to choose which material can be applied with the inquiry learning model.

In the development phase, formative evaluations are carried out consisting of self-evaluation, expert review, one-on-one evaluation, small group evaluations, and field tests. Furthermore, the research data was collected through LKPD validation sheets, RPP validation sheets, student response questionnaires, teacher response questionnaires, learning implementation observations and tests of mathematical problem-solving abilities in the form of essays.

The assessment stage is carried out by statistical tests using the design of the Posttest-Only Control Design from two randomly selected sample classes. This t-test One class represents the experimental class and one class as the control class. The steps in testing statistics are as follows: (1) collecting the results of problem-solving tests from both classes, (2) do normality and homogeneity tests, (3) make hypotheses, (4) conduct independent tests of T-test samples.

The T-test was conducted to see whether the effect of inquiry-based learning was better than direct learning. Inquiry-based learning is better than direct learning can be seen from the value of sig. (2-tailed). If the value of sig. (2-tailed) is small from 0.05 then H0 is rejected or H1 is accepted.

3. Results and Discussion

a. Device Validity

The Learning Implementation Design (RPP) in this study is inquiry-based where each step in the core activities in the RPP refers to the inquiry. In the preliminary activities, the teacher starts learning by inviting students to read prayers, check the attendance of students, motivate and explain the objectives in learning. The teacher explains the learning method first and tells students to sit in groups and distribute LKPD to students.

At the core activity, the teacher guides students in understanding the problems that exist in the LKPD by explaining what is asked for the problem and what students need to solve the problem. the next activity is guided students make hypotheses from problems that they already understand and each group is given the freedom to make hypotheses in accordance with the understanding and knowledge they have. The hypothesis that has been made will be proven at the end of the answer whether it matches the hypothesis that the student made or not.

The next activity the teacher guides students in designing experiments by taking steps to solve the problem given in groups. The steps are made in the form of a work order list in which each group is free to take steps to settle in accordance with the understanding of each group.

The next activity is conducting an experiment where the teacher guides the students to solve the problems given at the beginning of the LKPD in accordance with the steps the students have designed in the previous activity. Conducting an experiment and completing it is done in groups and it is expected that students will be more active in learning because if there are difficulties they are not ashamed to ask their own friends rather than their resources to the teacher.

The next activity was collecting and analyzing the data carried out by presenting the work of several groups to the next class chosen by the teacher. Each selected group explains the results of their work to friends according to their understanding and knowledge of the problem given. The results of the presentation of the work of several groups will be different. Next, the teacher asks the students to analyze the work of the group that appears whether it is correct or there are still errors that must be corrected.

The next activity the teacher guides students to draw conclusions from the results of collecting and analyzing data. The results of the work of each group will certainly vary according to the completion steps that have been designed at the beginning. All results can be correct even though the completion steps are different and here the role of the teacher explains that working on a problem can be done in various ways with the same results.

In the closing activity, the teacher concludes again and confirms again so that students understand the material or problem given. The teacher asks students to read the material for the next meeting and close the lesson.

After the lesson plan is designed according to the inquiry steps, it is then evaluated by yourself to see the mistakes made during the manufacturing process. These errors include typing class, punctuation, foreign terms used, text size and EBI usage. After repairs carried out continued with the validation of experts consisting of three mathematicians, one language expert, and one education technology expert. The results of the lesson plan validation by experts can be seen in the following table.

Table 1. Recapitulation of RPP Validation Results

No	Aspects Rated	Average	Criteria
1.	Subject Identity	3.8	Very Valid
2.	Components and format for RPP	3.5	Very Valid
3.	Formulation of Learning Indicators	3.4	Very Valid
4.	Formulation of Learning Objectives	3.5	Very Valid
5.	Selection of learning material	3.5	Very Valid
6.	Selection of the Learning steps	3.6	Very Valid
7.	Selection of Learning Resources	3.6	Very Valid
8.	Assessment	3.2	Valid
9.	Language and Writing	3.6	Very Valid
10.	Benefits of RPP	3.6	Very Valid
	Overall Average	**3.58**	Very Valid

Based on the results of 1 table, it can be seen that the results of the inquiry-based RPP validity test for each aspect are in very valid criteria and only on the assessment aspects are invalid criteria. Overall, the lesson plan developed is in a very valid criterion with an average score of 3.58 even though there are suggestions for improvement by the validator. So it can be concluded that the inquiry-based RPP developed is valid.

Educated Student Worksheet (LKPD) is designed based on needs analysis, curriculum analysis, concept analysis, and student analysis. Next, the evaluation is done to see errors in the manufacturing process. These errors include typing class, punctuation, foreign terms used, text size and EBI usage. Furthermore, the LKPD was validated by experts consisting of three mathematicians, one linguist, and one graphics expert. After the LKPD is repaired in accordance with the suggestions of the validator, the validator gives a value to the designed LKPD. The results of the assessment can be seen in the following table:

Table 2. Recapitulation of Results of LKPD Validation

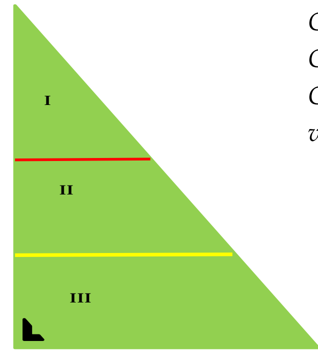
No.	Aspects Rated	Average	Criteria
1	presentation	3.23	Very Valid
2	Feasibility of content	3.1	Valid
3	Language	3.5	Very Valid
4	graphics	3.0	Valid
	Average Total	**3.22**	**Very Valid**

Based on the results in table 2, it can be seen that the inquiry-based LKPD developed for each aspect is in a very valid criterion. Overall, the inquiry-based LKPD developed received an average score of 3.22 with very valid criteria.

Inquiry steps in LKPD include (1) Presenting problems or statements, (2) making hypotheses, (3) designing experiments, (4) conducting experiments, (5) collecting and analyzing data and (6) making conclusions.

The activities carried out at the first meeting of the LKPD were students given problems and asked to find the concept of trigonometric comparisons on right triangles. In the activity of presenting the problem, students are asked to understand and pay attention to the problem in groups. The problems with the first LKPD are as follows:

"Father has a garden that will be planted with three types of vegetables in his garden, namely water spinach vegetables, spinach and carrot vegetables. Father divided the garden as shown in the picture below!



Garden I is planted with water spinach
Garden II is planted with spinach
Garden III is planted with carrot vegetables.

To limit the Janis vegetables in his garden, he holds a fence with a different color. A 15 m long red fence to limit between spinach vegetables and spinach vegetables in the meantime, a 30 m long yellow fence to limit between vegetable spinach and carrot vegetables. If the length of the father's garden to the east is 60 m, the north direction is 80 m, and the length of the garden planted with spinach and kale towards the north is 40 m, then is the circumference of the land planted with spinach equal to 1/3 of the whole garden?"

The next activity is to make a hypothesis of a problem that has been understood by students. The hypotheses made by students in each group are different and are written in the column provided in the LKPD. The orders given to the LKPD are as follows:

"Then please write down a temporary answer (hypothesis) from the problem question above!"

Some examples of hypotheses made by students are as follows:

- *"around the land planted with spinach more than 1/3 around the whole father's garden"*
- *"around the land planted with spinach less than 1/3 around the whole father's garden"*
- *"around the land planted with spinach with 1/3 around the whole garden of the father"*

The next activity is to design an experiment of the problems presented at the beginning of the LKPD. Students are asked to make completion steps in accordance with their understanding and knowledge. The orders given to the LKPD are as follows:

"Let's write down the steps to solve the problem above!"

Examples of designing experiments written by students are as follows:

Steps:

1. *Determine the circumference of ABC*
2. *Determine the circumference of the FGC*
3. *Determine the circumference of ABED*
4. *Determine the circumference of DEGF*
5. *Compare the circumference of ABC with the circumference of DEGF*

The next activity is to conduct experiments according to the steps made in designing the experiment. In this activity, students do calculations to find answers to the problems given. In this calculation, students will find the concept of trigonometric comparison with the help of right triangles in the image by dividing the image into three triangles that are congruent and the answers to the hypotheses students have made in groups. The orders given to the LKPD are as follows:

"Let's do an experiment to get data to help you solve the problems above."

The next activity is to collect and analyze data. In the activities of several groups, they were asked to present the results of their work. Students are asked to respond to what is conveyed by the group that is advancing to the class is right or there is still something wrong.

The next activity is to draw conclusions from the results of conducting experiments to answer the hypotheses students have made in groups at the beginning of the LKPD activities. The orders given to the LKPD are as follows:

"Based on the results of data analysis that you have done, check whether the hypothesis that you are submitting is acceptable or rejected and write the conclusion of the answer in the column below!"

Examples of conclusions made by students are as follows:

So the circumference of land planted with spinach is more than 1/3 around the whole father.

- *sin α = (front side of angle) / (hypotenuse)*
- *cos α = (side beside angle) / (hypotenuse)*
- *tan α = (front side of angle) / (side beside angle)*
- *cosec α = (hypotenuse) / (front side of the corner)*
- *sec α = (hypotenuse) / (side beside angle)*
- *cot α = (side beside angle) / (side in front of corner)*

b. Effectiveness

The effectiveness of learning devices is seen from the results of the test questions about students' mathematical problem-solving abilities made in the form of essays. The question was validated beforehand to three experts, namely two mathematicians and one language expert. The results of the final test validity of mathematical problem-solving abilities obtained an average score of 3.44 with very valid criteria even though there were improvements and suggestions from the validator. After making improvements to the problem of mathematical problem-solving capabilities can be used. The results of the average validity of inquiry-based learning tools developed can be seen in the following table.

Table 3. Results of Instrument Validation

No.	Type of Instrument	Results	Criteria
1	RPP	3.58	Very Valid
2	LKPD	3.22	Very Valid
3	Final Test Questions	3.44	Very Valid
Average Total		3.41	Very Valid

Based on table 3 it can be concluded that inquiry-based learning devices are in a very valid category and can be used to assist the learning process at school.

The results of the final test of students' problem-solving abilities in the Padang VOCATIONAL SCHOOL were conducted by t-test. To do the t-test, the normality test and homogeneity test are carried out first. Based on the tests carried out it was concluded that the data were normally distributed and had a homogeneous variance.

Table 4. Test t

		Levene's test for equality of variances		t-test for equality of means		
		f	Sig.	t	df	Sig. (2-tailed)
Nilai	equal variances assumed	.349	.559	2.146	61	.036
	Equalvariances not assumed			2.140	58.1	.037

Based on the Independent sample T-test table obtained sig. (2-tailed) value is 0.036 smaller than $\alpha = 0.05$ so H0 is rejected and H1 is accepted. Thus it can be concluded that inquiry-based mathematics learning devices have a significant influence on mathematical problem-solving abilities of class X SMK students.

c. Discussion

Inquiry learning begins with the presentation of problems so that students are familiar with problem-solving activities. This makes students become trained with problem-solving problems and skilled in completing them. This statement is emphasized by Turmudi (2008) that problem solving is an integral part of all parts of mathematics learning, and also does not have to be taught isolated from mathematics learning. Asikin and Pujiadi (2008) also said that teachers should provide more opportunities for students to solve problems in the form of problem-solving. Similarly, according to Sugiman et al. (T.t.), while studying mathematics, students should be trained to solve mathematical problems.

In inquiry learning, in the activity of understanding the problem students are used to identifying what they are trying to do and collecting information needed to support the discovery process. So that through this activity, students become skilled in selecting information that is needed and that is not needed, or in other word, students become accustomed to analyzing information from a problem at hand.

In inquiry learning, the experiment designing activities for discovery make students trained in determining various strategies that might be applied. This is supported by the statement of Poni Saltifa (2015) that this activity makes trained students determine the strategies that are considered most suitable to be run to assist the discovery process and are able to make students recognize several strategies in mathematics. This is supported by a statement from MOE Singapore (2007) that metacognition which is an aspect of problem-solving can be improved through activities such as asking students to get used to solving problems, training thinking skills, and heuristics in problem-solving, and encouraging students to identify strategies and the right method used to solve the problem.

In inquiry learning, in the activity of collecting and analyzing data trained students to compare the results, they get by trying it with other relevant strategies. This activity makes students critical of the solutions that have been obtained and accustoms them to re-checking whether the solution is reasonable or justifiable. This activity was concluded to increase the awareness of students to do the examination again in the stage of the problem-solving process. MOE Singapore (2007) also said that metacognition which is an aspect of problem-solving can be improved by giving students the opportunity to discuss how to solve a problem and explain the different methods they use in solving problems.

In inquiry learning, students collaborate in groups in the process of discovery so that students can exchange ideas or ideas. This is believed to be able to improve the performance of students. Effendi (2012) in his research also confirmed the same thing that group work is one method that can improve students' ability to solve problems.

Overall, the discovery activities of students in inquiry learning can train students in mastering the stages of the problem-solving process. In addition, inquiry learning allows teachers to monitor the development of students' abilities and find out at the stage where students often encounter difficulties. So that the teacher can immediately think of alternative learning to improve student weaknesses at that stage.

4. Conclusion

From the results of the discussion, it can be concluded that the learning device developed based on inquiry in the form of RPP and LKPD has been valid and can be used in the learning process of class X SMK. The results of the statistical test concluded that inquiry-based mathematics learning devices had a significant influence on the mathematical problem-solving abilities of class X students of SMK.

The development of inquiry-based mathematics learning tools for trigonometry material in class X SMK based on chemical analysis in the second semester in the form of RPP and LKPD has resulted in valid, practical and effective learning devices. Products developed are expected to be widely used to help teachers and students in the learning process of mathematics in schools, especially in developing mathematical problem-solving abilities.

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