The Development of Students Worksheet Using GeoGebra Assisted Problem-Based Learning and Its Effect on Ability of Mathematical Discovery of Junior High Students

Joko Suratno
Department of Mathematics and Science Education, University of Khairun
Email: joko_unkhair@yahoo.co.id

Abstract - Mathematical discovery have contributed to human life. There are many applications of mathematical discovery in economics, social, culture, and information technology and computer. To create students which have ability to discover mathematic needed an appropriate learning approach. One of the alternative approaches which can be used is to combine between GeoGebra and Problem-Based Learning (PBL). This study aims to get a worksheet which combining between GeoGebra and PBL, to get good quality of students’ worksheet, and to analyze its impact on students’ ability of mathematical discovery. This study was a research and development study conducted in MTs Negeri Kota Ternate, North Maluku. The data collect were those on the quality of the developed worksheet and students’ ability of mathematical discovery collected through evaluation form and a test. The data were analyzed using SPSS. Based on the study, the following conclusion can be drawn. (1) The quality of students’ worksheet can be categorized in good criteria, (2) There is an effect of developed students’ worksheet on students’ ability of mathematical discovery, and (3) Students’ ability of mathematical discovery taught by developed worksheet is higher than those taught by traditional approach.

Keywords: geogebra, mathematical discovery, problem-based learning

I. INTRODUCTION

Mathematics is a science that has many roles in the development of individuals and society [1]. Mathematics is needed to help intellectual development. As an example, problem-solving activities in mathematics which assist students in the development of thinking. In the development of society, the role of mathematics can be seen in various fields, for example in education and development of science and technology. As a tool in support of science and technology, mathematics should be developed and be applied in everyday life in a variety of tools and technologies. Therefore, the world waits for more discoveries in mathematics as an effort to improve the life of mankind. Surely the role of a mathematician is needed in the new invention because a growing number of mathematicians, the more new discoveries.

One way to increase a lot of mathematicians is to cultivate and educate prospective mathematicians in the school. Therefore, teachers need to enhance them role in creating new inventors in mathematics. However, at this time most math teachers only produce students or graduates who have little mathematical skills and do not have the knowledge or experience in the discovery of mathematical [2]. In addition, although some mathematics textbooks featuring a conjecture in the presentation of the material but learning activities in schools today is felt its characteristics. It is apparent from the reduced mathematical algorithm presented by the teacher in explaining the material; students do not learn why it requires mathematical conjectures and concepts; they rarely discover why definitions, examples, theorems, and the evidence is very important or interesting; and students think that learning mathematics is just learning about the rules and rigid measures [3].

Each student would not have to be a mathematician or good at mathematics. But students need to master mathematics early in the technological development. Therefore, equip learners with the ability of mathematical discovery is needed, so that learners can have the ability to find patterns that occur in real...
life is always changing, uncertain and competitive. By finding patterns that occur in everyday life, students are expected to predict and solve a problem that will be and are being faced.

Mathematical discoveries in the classroom are only possible at an appropriate learning environment. The use of multi-strategy approach and the use of technology can be used as a tool in mathematical discovery. However, it has become common that the learning strategies used by teachers not changed much until now. Mathematics teachers still use traditional learning in the classroom. Where, learning activities centered on the teacher as a source of information. Teachers spoke at the beginning of the lesson, explaining material and sample questions and presents exercises that should be done by students. Most mathematics teachers rarely or never taught with technology so that the integration of technology in learning mathematics progressing very slowly. In addition, some teachers actually have access using a computer and suitable software both at school and at home, however, the technology and the facilities there are rarely integrated by teachers in teaching on a regular learning [4].

Characteristics of learning activities that allow generates an discovery is a learning activity in which there are activities that allow students to be able to make observations. Of course, these observations based on a task/activity and problems that allow the students to acquire a variety of results, make mistakes, make improvements, and summed up the results that have been obtained. One alternative approach to learning that has these characteristics is a problem-based learning (PBL). It is possible because of the discovery of several mathematical discoveries that is the solution of a problem or activity. In addition to PBL, technology (computers) can also be used as a tool in mathematical discovery activities [5]. Technology has affected the world of education today. That is because the availability of various hardware and software and the means or information and communications technology (ICT) that can be used by students to learn. ICT least affect subjects in school, knowledge, curriculum, how the work of experts, the way teachers teach, how students work either individually or in groups, and the way students learn. That influence has consequences for the competence of teachers and has implications for teacher. Teachers should also be able to use these technologies both in the classroom and the laboratory [6].

The availability of technology (computers) and various software whether paid or free should not make an excuse for teachers not to use such software in learning. There are at least three groups of software commonly used in mathematics. There is a dynamic geometry software or dynamic geometry software (DGS), the computer algebra systems (CAS) and spreadsheets [7]. However, software that is widely used in mathematics only two, namely the dynamic geometry software and computer algebra system [8].

Development of technology today has encouraged software developers to try to combine multiple types of software into single software, one of which is GeoGebra. GeoGebra is dynamic mathematics software for all levels of education that combine arithmetic, geometry, algebra, and calculus [9]. GeoGebra can be used in learning-oriented activity and problems [10]. GeoGebra developers expect that with this software mathematics will be easily understood. He also wanted to show to students that mathematics is very useful and interesting. With GeoGebra students can play with mathematics. They can do quickly, drag the point wherever they want, can experiment with mathematics, and make a better understanding in the students [11]. Therefore, introducing GeoGebra is the right way to improve the quality of learning and is expected to improve student learning achievement [12]. With GeoGebra, students can see the abstract concepts, make connections, and discover mathematics [9] and reduce calculation errors when compared with calculations by hand [13]. GeoGebra provide flexibility to students to investigate deeper into a geometric shape. They can express various things that may not be found or do when they use paper and pencil in constructing geometric objects [14]. Additionally, GeoGebra can give students the opportunity to conduct an investigation, observation theorem, and make conjecture [15].

PBL provides more effective effect in the study of mathematics as compared with the traditional learning in improving the understanding and use of mathematical concepts of students in real life [16]. In addition, technology is important in the learning of mathematics [17]. However, integrating GeoGebra in learning activities with the PBL approach is not easy [18]. Fewer training materials about PBL [19] and the availability of computer labs are not enough to guarantee the implementation of the use of computers in the classroom on regular learning activities [20]. Therefore, the development of materials or instructional materials that integrate technology into PBL through the development of this research is
essential to solve the challenges or problems that occur in learning. Specifically, this study also addresses the challenges of the slow progress in the integration of technology in learning mathematics [4]. This research is also expected to solve the difficulties students understand the material presented teachers, motivate teachers to be able to share his knowledge to students, and helping to organize knowledge so that students learn better when study with PBL [21].

II. Method

This study is a Research & Development (R & D). Educational Research and Development is an industry-based development models in the which the finding of research are used to design new products and procedures, the which then are systematically field-tested, evaluated, and refined until they meet specified criteria of effectiveness, quality, or similar standards [22]. Educational research and development (R & D) is a process used to develop and validate educational products [23]. The major purpose of R & D Efforts is not to formulate or test theory but to develop effective for use in schools [24]. Products of the research and development of teaching materials may include teacher training, teaching materials, instruments related to psychology, teaching materials in the form of media, and management systems. There are two things that must be considered by researchers in the development of a prototype product of research and development. First, if researchers make their own prototype model, the researchers will make themselves as the applicable procedures. Second, if the researchers chose to make modifications to the products available, the researchers simply adjust some aspects or working procedures in accordance with the circumstances of the desired [25].

The research model in this study is a model of research and development in the field of education that aims not to formulate or test the theory but aims to produce learning materials in the form of teaching materials that include lesson plans and worksheets. In addition, this study aims to develop a prototype of its own, which means that the prototype model developed will be made based on the applicable procedures. The procedure of research development in this research is the combining and adjusting the model or procedure based on some procedure of research and development. The procedures of the study include research and information collecting, planning, develop preliminary form of product, screening, expert appraisal, and try-outs.

The main purpose of research and development is not for the formulation and testing theories but to develop teaching materials to be used in schools [24]. To get quality teaching materials, the instructional materials will be developed through a process or stages of curriculum development. The first step taken is to perform the analysis on the initial activity, then performed a formative evaluation repeatedly aimed at improving the quality of products that have not been finished and continued with summative evaluation at the end of a process that aims to assess the effectiveness of the final product.

Formative evaluation aims to improve product quality and summative evaluation aims to determine effect and effectiveness of the product [26]. Formative Evaluation of the study include screening and expert appraisal and summative evaluation is done through try-outs (the trial). Product research in the form of lesson plan (LP) were evaluated by experts (expert appraisal) to see the extent to which the LP completeness or suitability of the material being taught. LP components are assessed include the completeness of the identity of the subjects; suitability indicators with; conformity with the purpose of learning competencies; the suitability of teaching materials to the learning objectives; the suitability of teaching methods to the learning objectives; featuring activities introduction, core, and cover with clear; suitability of learning resources with standards of competence; and conformity assessment with indicator of achievement.

Each expert gives a score of 1 if the components in each of the LP incomplete, giving a score of 2, if the components are rated less complete, and gave a score of 3, if it is complete. Furthermore, the average score of each expert summed to obtain an average, which are used as an assessment of each LP. LP quality criteria can be determined based on the following table.
TABLE 1. QUALITY CRITERIA OF LESSON PLAN

<table>
<thead>
<tr>
<th>Average Score (X)</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>X ≥ 2.33</td>
<td>Complete</td>
</tr>
<tr>
<td>1.67 ≤ X &lt; 2.33</td>
<td>Less Complete</td>
</tr>
<tr>
<td>X &lt; 1.67</td>
<td>Incomplete</td>
</tr>
</tbody>
</table>

Students worksheets (SW) evaluate based on some components that will be used as a reference to determine the quality of SW developed. Component SW assessed based on four main components which include the feasibility of the content, language, presentation, and graph. SW experts assess the value of 1 if the component is not very good, value 2 if the component SW is less appropriate, value 3 if the component SW enough, value 4 if the component SW good, and value 5 if the component SW very good. The average value of all experts will be used as a reference for determining the quality of SW. SW quality assessment in question can be seen in the following table.

TABLE 2. QUALITY CRITERIA OF STUDENTS WORKSHEET

<table>
<thead>
<tr>
<th>The average score (X)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.01 &lt; X</td>
<td>Very Good</td>
</tr>
<tr>
<td>3.34 &lt; X ≤ 4.01</td>
<td>Good</td>
</tr>
<tr>
<td>2.67 &lt; X ≤ 3.34</td>
<td>Enough</td>
</tr>
<tr>
<td>2.00 &lt; X ≤ 2.67</td>
<td>Not Good</td>
</tr>
<tr>
<td>X ≤ 2.00</td>
<td>Very Not Good</td>
</tr>
</tbody>
</table>

After the expert appraisal is completed, the next step is doing summative evaluation of the products developed by experiments, by comparing the results of the development of products with other products. The experimental design which used in this study with is a quasi-experimental design. Type of quasi-experimental design used is posttest design. Researchers chose this kind of design because of its simplicity [27]. Subject of try out this study were students of class VII MTs Kota Ternate (Grade 7 of Junior High School). Subjects of try out the summative evaluation stage are class VII6 and class VII7. Class VII6 used as experimental class and class VII7 used as a control class.

The main instruments of this study are test of mathematical prior knowledge and test of mathematical discovery. Mathematical prior knowledge test is a test used to measure students' understanding of the material of the material that has been learned and predicted a support material in the material master triangle and quadrilateral. Test of mathematical discovery will be used to determine the ability of mathematical discoveries of students in finding relationships or properties in mathematics that can be done by generating a conjecture or theorems, identify deficiencies or simplification of evidence, and product a new method which one example is the strategy of new proof. The instrument measures the student's ability to generate conclusions about relationship midpoints of the sides of a rectangle and a wake formed by the midpoints; generate conclusions about the properties of the line formed by the relationship between the diagonal lines, median, and a line parallel to the side of the trapezoid; generate conclusions about the relationship between the properties of diagonal lines and the area is divided by a diagonal in the parallelogram; and generate conclusions about relationship angles in triangles and lines for the triangle. Both of these instruments have been tested base on the stages of the test items.

Data of quality teaching materials developed analyzed by deskriptif statistics and data of ability of mathematical will be analyzed using SPSS (Statistical Product and Service Solution). Data will be detected their outliers and data will be tested their assumptions of normality and homogeneity of variance. Outliers detected using z scores. Datum which has z scores around the absolute value of the 3 suspect as outliers. Therefore, the data are normally distributed approximately 99% should lie within 3 standard deviations from the average [28]. Therefore, the data that had z scores around three will be specifically noted. The assumption of normality is a requirement mostly inferential statistical procedures.
SPSS provides two formulas normality test, which Lilliefors normality test (Kolmogorov-Smirnov) and Shapiro-Wilk normality test. Theoretically, the normal curve has become a useful mathematical model for the statistics, because the connection with the central limit theorem [29]. A variable is said to be normally distributed or have a normal distribution if the distribution has the shape of a normal curve [30]. The research data also requires the assumption of normality because characteristics education research data which correspond to the normal curve. Test of homogeneity of variance using Levene test. This test is mostly used in parametric statistical tests. Moreover, the assumption of homogeneity of variance was also one of the assumptions that must be done in nonparametric statistical tests [31]. However, this assumption is not commonly used in nonparametric statistical test [32]. Therefore, if the normality assumption is not met, then the homogeneity test was not carried out further. If the assumptions of normality and homogeneity are met, the research hypothesis will be tested by paired t test. If the normality assumption is not met, then the first research hypothesis will be tested with the Mann-Whitney test.

III. RESULTS AND DISCUSSION

A. Quality of Instructional Materials

Teaching materials used in this study include Lesson Plan (LP) and the Student Worksheet (SW). The material studied in this research is based on Curriculum 2006. Curriculum materials include Triangle and Quadrilateral. In this study the material organized into ten lesson plan that includes a discussion of the properties of the Triangle; The properties of the Rectangle and Square; The properties Trapezoid and parallelogram; The properties of a Rhombus and Kite, Area of Rectangle and Square; Area of parallelogram and Trapezoid; Area of a Triangle and Rhombus; Area of Kites; Constructing Triangle and the Lines in the Triangle.

Before being used in research, LP were evaluated by experts to see how far the completeness or suitability of the LP with the material being taught. Experts who evaluated the LP are three experts. Data of expert analysis on the quality of LP showed that only 1 LP which shows the average value of 2.96. Besides LP 1, the average value of score of quality for other LP is 3.00. Therefore, based on assessment of the three experts pointed out that the lesson plan can be categorized into criteria are complete. The experts also stated that all LP can be used without revision. Student Worksheets (SW) this study are ten. The SW is named from SW-1 up to SW-10. Based on the average score of each SW of the three experts, it can be pointed out that all worksheets can be categorized into criteria Very Good. Overall experts also stated that the worksheets are created can be used without revision.

B. Data of Try-out

Teaching materials have been assessed by experts then tested. Test of teaching materials conducted in MTs (427) Kota Ternate. Sample classes used as the try out phase are Class of VII6 and VII7. Class of VII6 used as an experimental while Class of VII7 used as the control. Before learning activities both classes are tested to determine the prior knowledge of students. By removing some data suspected as outlier, it was concluded that the both of class eligible to be used as a sample class in this research. The findings obtained during the course of the trial as a reference for the improvement of teaching materials. LP and SW trials do not face significant obstacles. However, there are few constraints, especially related to students’ skills using a ruler, protractor, and the period during learning in the classroom. Several obstacles that include less-skilled students to use a ruler, some of them calculate the length of the sides did not start with the number 0 but 1, most of them are not able to use a protractor correctly. In addition, the selection of the arc that supports the learning activities must also be noted. As the following examples are presented images that researchers recommended and not recommended in the selection of a protractor.
As an example of the difficulty of students using a protractor was showed in Figure 3.2. The difficulty of students found in research activities was when the students calculate the angle of 70°. Pictures were a little small to be enclosed pictures of bees. It was causing students facing difficulty calculating the angle. To resolve this problem, the researchers took the initiative so that students are using tools, for example, students can use the paper when using the protractor like this. For example it showed in Figure 3.3.
Changes that occur in try-out of instructional materials are adding the number of each one meeting both in the classroom and in the laboratory. The addition of class activities aim to improve students’ skills in using tools such as a ruler, protractor, and compass. The addition of one session in the laboratory was to equip students in the introduction of several tools that will be used in learning activities with the program of GeoGebra.

On going evaluation done at this preliminary stage and this stage ends with a series of tests of mathematical discovery ability of students. Test results showed that there were significant differences between the ability of mathematical discovery ability of these two classes. Students’ mathematical discoveries ability taught with problem-based learning aided dynamic mathematics software GeoGebra higher than Students’ mathematical discoveries ability taught traditional teaching.

Knowledge can only be derived from experience [33]. Efforts to provide GeoGebra software assisted problem-based learning experience to gain knowledge of mathematical discoveries have been able to meet expectations. It is thought to relate to the mastery of basic skills are mastered by the student, such as understanding the symbols and terms. Therefore, efforts to maintain this situation are to re-construct the prior knowledge through learning design that has been improved so that the advantages contained in the PBL can be maximized. An example is to maximize the role of cooperation in groups where individuals can mutually help each other in constructing knowledge through social interaction and culture [34].

The prior knowledge that students have mastered a necessary condition to make a conjecture by following the instructions presented. Most of the students in this study suggest that they do follow the instructions given and some others still have a problem in the use of tools, such as the compass and protractor. Although finding the conjecture is the first step in discovering mathematics [35] but with not good abilities of the students will cause problems for students to gain conjecture expected.

There are similarities with the research results of several previous studies. Previous studies showed that problem-based learning has effect to increase a variety of mathematical ability of students. One study concluded that the quality improvement of the ability to think critically, creatively, and mathematical reflective and self-regulated learning by using problem-based learning is better than the students who are learning mathematics traditionally [36]. Problem-based learning also showed better results when compared to traditional learning in terms of improving mathematical communication skills, mathematical problem solving ability, mathematical disposition of students [37].

Problem-based learning is superior to traditional learning in enhancing the ability of mathematical reasoning, mathematical communication, and emotional intelligence of students [38]. Problem solving skills, communication, and the mathematical representation of students who get problem-based learning was better than students who received traditional learning [39].
The combination of problem-based learning model or other strategies also showed good results. This can be demonstrated by the high-level mathematical thinking skills and self-regulated learning of students using problem-based approach to setting Jigsaw type of cooperative is better than the high-level mathematical thinking skills students are learning to use a problem-based approach [40]. The ability to think critically, creatively mathematical, and attitudes of students who received problem-based learning with cognitive conflict strategy was better than students who received traditional learning. Combine above suggests that problem-based learning is an instructional approach it is possible to be combined with learning, strategy, or other learning tools [41].

Integrating technology (GeoGebra) in PBL apparently showed satisfactory results. Separately GeoGebra can make students better understanding [11]. Additionally, with the ability to visually GeoGebra, students can also see the abstract concept [9]. Ease of use GeoGebra also allows users to conduct investigations, observing theorem, and make conjecture [15] that GeoGebra can be used in mathematical discovery [10].

In essence, combining the advantages of PBL and GeoGebra is something very interesting. PBL can affect the motivation of students [42]. On the other hand, GeoGebra can help students to learn mathematics well [12]. High students' motivation to learn is supported by the media that makes learning better is one of the modals can be maximized to get better learning outcomes. PBL requires the active participation of students in the class [16] and GeoGebra provide flexibility to students to learn and discover the properties of geometric objects [14].

Application of PBL and GeoGebra in the classroom this research has an impact on the ability of students' mathematical discovery. PBL learning environments expecting many solutions to the problems presented in the study. It is expected to be a valuable experience of students who certainly will not be found in traditional learning activities. PBL expects students to have the skills of problem solving and critical thinking [42] and support GeoGebra as a medium to improve the quality of learning [18] is expected to train a variety of skills, one of which is the skill of reasoning [43]. Reasoning ability is important in mathematics and mathematical reasoning is a key part of mathematical discovery [44].

IV. CONCLUSIONS

The main objective of this research is to produce instructional materials that meet the criteria expected and have a better impact in mathematics. Based on analysis data conclude that the teaching materials developed have met the criteria expected and have a better impact than traditional learning. Therefore, the researchers recommended that the teaching materials developed can be used in advanced research stage or can be used in the classroom.

Researchers who want to do research related to technology should consider two things. The first is the selection of the appropriate method or approach to a subject matter and the ability of students to be developed. It requires thinking how to look at the problems faced by students up to look for alternative solutions. The second is the allocation of time between activities in the laboratory and in the classroom. More or less time in the lab activities will certainly affect the ability of students to be measured. The learning activities which all activities are spent at the computer laboratory certainly will affect the students' ability or skill in using geometric construction tools, such as ruler, compass, and protector. One of the recommendations of researchers for researchers who study geometry problems with technology are necessary to be undertaken a study evaluating the impact of the quantity of learning activities in a computer lab on the ability or the student's skills in constructing a geometric object and find out the percentage of ideal between the number of hours of activity in the laboratory and in the classroom so that the student's skills in constructing geometrical object either manually nor using technology be able to enhance.

REFERENCES


