Development of learning media based on to improve the mathematical problem solving abilities of grade 11 senior high school student

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Abstract. As it was found in many schools, the learning media have not helped educators in facilitating students in supporting an effective learning process. Learning tools which consist of a syllabus, lesson plans, teaching materials and learning outcomes tests that were used do not involve students actively. One effort that can be used is through discovery learning methods that are valid, practical and effective. Where this method was implemented by connecting the concept of learning with problems in everyday life and aimed to improve students’ problem-solving abilities and teaching them how to solve problems until new knowledge was discovered by students. The aimed of this development was to produce a learning media based on discovery learning by using GeoGebra on valid and practical for second semester topic. This type of research was a development research using the Plomp development model which consists of three phases where the initial investigation, the development phase and the assessment phase. The research subjects were students of class grade 11 in Senior High School Number 2 Pulau Punjung. The results of the validity of the data analysis indicated the discovery learning were in valid criteria in terms of content and validity of lesson plan with a percentage of 86.78% and the validity of worksheet was 82.24%. Practicality of learning media, attractiveness, comfort and time efficiency were 95% based on teacher questionnaire responses and 85.30% questionnaire responses for student learning media with discovery leaning method and the affectivity of discovery learning in term of completeness was 83. 87%.

1. Introduction
Mathematics is a branch of science that plays an important role in the development of science and technology, notably as a tool in forming thinking patterns and shaping attitudes. Mathematics also create human character and help human to think logically, practically, carefully, obey principles and are able to solve problems quickly and precisely. All of those requires mathematical conceptual ability. Students must have five mathematical abilities, namely: concept understanding, communication, reasoning, problem solving and connection [1] and based on the Minister of Education and Culture, one of the objectives of learning mathematics in high schools is that students have high-level thinking skills such as mathematical problem solving abilities. However, in Indonesia, the mathematics learning result of students from elementary to university level are still low [2-14]. This is because the orientation of education in Indonesia still relies on knowledge (cognitive aspects), whereas in developing countries...
mathematics is directed at expert thinking which includes analytical skills, problem solving, and curiosity.

Lack of problem-solving abilities is due to teachers not involving students in problems that challenge the thinking process [13]. Students are not accustomed to work on problem solving, students are more likely to memorize formulas, copy formulas according to problem needs and work on routine questions. So that for non-routine or different problem solving questions, students are unable to apply and use the concepts they already have on non-routine real life problems.

The problem of mathematical problem solving ability needs to be solved so that students no longer have low problem solving abilities. One of the solutions is to improve the learning process by developing the learning media. The learning steps made in the learning media are steps of routine activities, namely: students are given concepts and examples, working on exercises in textbooks which are similar to the examples taught by the educator. If this happens continuously, it will cause boredom in students so that students will be less motivated when learning. Another fact that was found was that the material presentation technique in textbooks and student worksheet provided by the school had not involved students actively in concept discovery and in improving students' problem solving abilities.

The solution to solve these problems is that it is necessary to develop the learning media in term of lesson plan and worksheet that can help teachers and students to achieve learning goals and support the implementation of fun and meaningful learning, by linking the concept of lessons with problems in everyday life so that it will support the ability of students to solve problems [6]. In addition, a learning method is needed that can be used as a basis for developing learning media. One of the efforts that can be used is through the discovery method, where this method is implemented by linking the concept of learning with problems in everyday life and has the goal of improving students' problem-solving abilities and teaching how to solve a problem until new knowledge is found by students.

Discovery learning is a method that use problems as a first step in gathering and integrating new knowledge. This problem is used to link the curiosity and analytical skill of students. discovery learning will help students to think systematically, students will dare to face and solve problems, both problems in their personal and group lives by looking for data then processing and finally solving these problems to get a conclusion.

In addition, based on one of the objectives of learning mathematics, Permendikbud No.59 of 2014, concerning the use of simple teaching and technological results to apply mathematical activities. Researchers also take advantage of the fast development of technology in facilitating and doing many things, including developing the world of education. One application or computer program that can be used as a medium for learning mathematics, especially in Geometry, Calculus, and Algebra is GeoGebra. It was developed by Markus Hohenwarter, which is a dynamic and free application that can be used by anyone, including students.

The purpose of this research was to produce a valid, practical and effective mathematics learning media based on discovery learning by using GeoGebra in the second semester of grade 11 senior high school students.

2. Materials dan Methods
The type of research used was Research and Development (R & D) which aimed to determine the process and results of developing learning media based on discovery learning by using GeoGebra in mathematics subjects for grade XI, Senior High School level and they were valid, practical, and effective. This study used the Plomp development model, because this model has been widely used by researchers in conducting research and development. The Plomp development model consists of 3 stages, namely the preliminary research phase, development or prototyping phase and assessment phase [15]. The instruments used and the objectives of data collection can be seen in Table 1.
Table 1. Details of data collection activities in needs analysis

| Method of data collecting | Instrument                  | Purpose                                                                 |
|---------------------------|-----------------------------|-------------------------------------------------------------------------|
| Interview                 | Interview guidance          | Uncover the obstacles encountered by the teacher, the learning models,   |
|                           |                             | methods and resources used, the learning resources expected, and the    |
|                           |                             | teacher’s responses to the development of learning media based on       |
|                           |                             | discovery learning.                                                     |
| Observation               | Observation sheet           | Observe the implementation of the teacher's role as a facilitator who   |
|                           |                             | teaches students.                                                      |
| Questionnaire             | Questionnaire               | Expressing students' perceptions of mathematics, the specification of    |
|                           |                             | learning resources that students expect.                                |
| Primarily test            | Test questions on          | Identify the initial conditions of students' mathematical problem       |
|                           | conceptual understanding   | solving abilities.                                                     |
|                           | and mathematical reasoning |                                                                         |

3. Results and Discussion

3.1 The result of preliminary research phase
The development of PBL-based mathematics learning instruments began with the preliminary research phase. The information obtained in the needs analysis is that the learning process is still focused on the teacher, the learning resources used by the teacher are not sufficient, and mathematical communication is still low. Based on the mathematical communication test results, where many students got grades below the Standard of Minimum Completeness (KKM). Besides, students tend to like group learning process; they also like the daily life associated learning material. This observation was used as a basic for developing PBL-based learning instruments implemented in LKPD.

3.2 The result of Development or prototyping phase
At the development stage, discovery learning model was designed to be developed which was a suitable to be applied for grade XI students. The results of the design were then evaluated to see the errors found in the learning media. There were several errors in learning media such as typing errors. There were two aspects evaluated in the lesson plan, namely typing errors and the accuracy of using punctuation marks. Whereas in worksheet there were five aspects evaluated, namely, typing errors, accuracy in using punctuation marks, accuracy in text size, misplacing of images, availability of empty spaces to solve problems found in worksheet. then made corrections to these errors. The equipment that had been revised was validated by 5 experts consisting of 3 material experts who understand mathematics material, 1 linguist and 1 media expert. The results of lesson plan validation were component aspects and indicators of competency achievement indicators, learning objectives, teaching materials, approaches, learning models and methods, learning steps, learning resources and learning tools, assessment, language and writing, and the benefits of lesson plans, the percentage is 86.78% with a very valid category and made several revisions after being tested by experts.

Worksheet validation was validated by 5 validators, namely 3 mathematics education experts, 1 Indonesian language expert and 1 educational technology expert to validate the display aspect, the validator suggested that the steps in the guided discovery stage did not provide material to students, only in the form of columns blank to solve the given problem. The results of the worksheet validation obtained the percentage of 82.24%. with a very valid category and several revisions were made, examples of revision results can be seen in Figures 1 (a) and 1 (b).
Figure 1. (a) before revision, (b) after revision

After the worksheet was been validated and revised, then a one-to-one test was applied with the aim of asking for input on the product being developed. Individual evaluation was carried out on 3 students from Senior High School Number 2 Pulau Punjung who had different abilities, namely one high ability person, one medium ability person and one low ability person. Individual evaluation was aimed to identify possible errors such as poorly understood grammar, incorrect spelling, punctuation, unclear instructions, suitability of examples, systematics of the material, ease of use, attractiveness, and satisfaction.

When observations were made, students who were highly capable and moderate could understand well the content of the worksheet material and the explanation of the material so that students were able to find solutions to problems from the questions. Meanwhile, students with low abilities still needed the guidance of researchers to make sure the information they write was correct, they still looked confused and seemed to have repeated understanding the explanations from the worksheet. When reading the derivative material of Algebraic functions in the drawing section of the graph of the derivative, students found several errors such as repetition of sentences at the stage of finding problem solving number 9 with number 10, besides that students also found typing errors and incomplete steps of use GeoGebra to graph the derivative curve of algebraic functions, so that revisions and additions of sentences were made in that section. One of the revised results can be seen in Figure 2. In Figure 2, it can be seen the typing errors, repetitions and incomplete sentences which are later changed to be more effective and complete.

After the worksheet was revised, then an evaluation was applied by giving a questionnaire to the small group aimed to see the practicality of using worksheet which included learning progression, suitability of time allocation, and convenience. The evaluation was to 6 grade XI students of Senior High School Number 2 Pulau Punjung. The results of the small group trial on worksheet obtained an average of 83.87% within the practical category. In addition, a practicality questionnaire was also given to teachers which aimed to see the practicality of the use of learning tools (RPP and LKPD) based on predictions and considerations of mathematics teachers in grade 11 of Senior High School Number 2 Pulau Punjung. The test results obtained an average of 95% with the practical category. The results of the analysis indicated that the learning media based on Discovery learning by using GeoGebra could be used for classroom learning. After the worksheet was revised, then an evaluation was applied by giving a questionnaire to the small group aimed at seeing the practicality of using worksheet which included learning progression, suitability of time allocation, and convenience. The evaluation was on 6 grade 11 students of Senior High School Number 2 Pulau Punjung. The results of the small group trial on worksheet obtained an average of 83.87% within the practical category. In addition, a practicality questionnaire was also given to teachers which aimed to see the practicality of the use of learning media
based on predictions and considerations of mathematics teachers in grade 11 Senior High School Number 2 Pulau Punjung. The test results showed an average of 95% within the practical category. The results of this analysis indicate that the discovery learning could be used for learning process.

![Image](image_url)

**Table 2.** Overall results of user response testing

| Respondent | Result (%) | Category   |
|------------|------------|------------|
| Teacher    | 87.20      | Very practical |
| Student    | 82.30      | practical   |
| Average    | 84.75      | practical   |

**Table 3.** Student learning test results

| Post test | Passing grade | Total |
|-----------|---------------|-------|
|           | Passed        | Not passed |
| Number of Student | 25 | 8 | 33 |
| Percentage | 75.76% | 24.24% | 100% |

In table 2, the overall practical value of the learning media based on Discovery Learning obtained from teachers and students was 84.75% which was in the practical category. So that mathematics learning media by using GeoGebra was classified practical and suitable for use as a source of independent learning. Table 3 shows the results of learning tests of students with 33 students or 75.76% of students who pass and 24.24% of students who did not pass. Students did not focus during the discussion and did not seriously do the exercises, causing students not to be able to answer test questions.
well. From the results of these tests, it was known that more than 70% of students had pass. Thus it could be concluded that the learning media based on discovery learning by using GeoGebra was effective.

4. Conclusion
This study created a valid, practical and effective learning media. The validity of learning media is shown from the results of expert assessments. The practicality of learning devices is shown from the responses of teachers and students who can use learning tools well, can help students understand the material, and students are interested in using it. The effectiveness of learning media is indicated by the percentage of students’ learning completeness after using learning media which is more than 70%.

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