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Development of Project-Based Worksheets integrated with Geogebra

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Abstract: This research aims to develop project-based student worksheets with the help of Geogebra that meet the criteria of being valid, practical and effective for students in the mathematics education study program at Bung Hatta University. This research is development research that uses the ADDIE development model with the steps, namely Analysis, Design, Development, Implementation, and Evaluation. The research subjects involved 14 students in the 6th semester of the mathematics education study program. The instruments used in the research included validity questionnaires, practicality and effectiveness tests on student worksheets. Data analysis was carried out by calculating the average expert validation score and the average score of the student response questionnaire. Meanwhile, testing the instrument for testing the effectiveness of student worksheets was carried out using item analysis and internal consistency of test items. The results of data analysis show that the student worksheets developed are in the valid category with an average level of 82%, practical with an average of 81.25%, and effective with an average of 81%. Thus, it can be concluded that the project-based student worksheets assisted by Geogebra are in the valid, practical and effective category for use in the learning process by students.

Keywords: ***Lembar Kerja Mahasiswa, Proyek, Geogebra***

Abstrak: *Penelitian ini bertujuan untuk mengembangkan lembar kerja mahasiswa berbasis proyek dengan bantuan geogebra yang memenuhi kriteria valid, praktis dan efektif untuk mahasiswa program studi pendidikan matematika di Universitas Bung Hatta. Penelitian ini adalah penelitian pengembangan yang menggunakan model pengembangan ADDIE dengan langkah-langkah yaitu Analysis, Design, Development, Implementation, dan Evaluation. Subjek penelitian melibatkan 14 mahasiswa semester 6 program studi pendidikan matematika. Instrumen yang digunakan dalam penelitian meliputi angket validitas, praktikalitas, dan tes efektivitas lembar kerja mahasiswa. Analisis data dilakukan dengan menghitung rata-rata skor validasi ahli dan skor rata-rata angket respon mahasiswa. Sedangkan ujicoba instrument test efektivitas lembar kerja mahasiswa dilakukan dengan analisis butir dan konsistensi internal butir tes. Hasil analisis data menunjukkan bahwa lembar kerja mahasiswa yang dikembangkan memiliki kategori valid dengan tingkat rata-rata sebesar 82%, dikategorikan praktis dengan rata-rata sebesar 81,25%, dan efektif dengan rata-rata sebesar 81%. Dengan demikian dapat disimpulkan bahwa lembar kerja mahasiswa berbasis proyek berbantuan geogebra berada pada kategori valid, praktis, dan efektif digunakan dalam proses pembelajaran oleh mahasiswa.*

Kata kunci: *lembar kerja mahasiswa, proyek, geogebra*

▪ INTRODUCTION

In the era of the industrial revolution, technological progress is increasingly rapid and has a positive impact on the world of education because it can facilitate the dissemination of learning information (Setianingsih et al., 2018). The world of education has the opportunity to improve classroom learning with the help of technology (Coto, 2008). To adapt to changing times, teachers and students must have technological

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knowledge and expertise (Sholihah & Purwanti, 2021). Over the years, the use of technology in education has emphasized the importance of student-centered learning and the role of teachers as facilitators (Alkhateeb & Al-duwairi, 2019; Aman, Fatimah, Hartono, & Effendi, 2017; Kepceoğlu & Yavuz, 2016).

Previous learning was carried out conventionally by relying on textbooks. However, digital technology is starting to replace this role (Samala et al., 2020). The world of education has a digital system that allows teachers and students to learn anytime and anywhere. According to Mohd Zairul (2020), modern learning methods utilize technology to build a smart learning environment.

Teachers refer to the learning model when implementing learning. According to Khoerunnisa & Aqwal (2020), the learning model itself is an outline of procedures that combine systematic syntax to optimize learning outcomes and achieve learning goals. Project-based learning is a learning model that is considered in accordance with the independent curriculum and is considered suitable for integration with advances in information and communication technology (Wibowo et al., 2022). Project-based learning is more empowered in the independent curriculum, with additional hours of up to 20% of the total lesson hours each semester (Kemdikbudristek, 2022).

The syntax of project-based learning includes developing interest and project determination, planning, implementation, and drawing conclusions; This model encourages students' creativity, problem solving, and communication skills (Karnando et al., 2021). This model also allows students to work in groups or independently. (A. R. K. Nisa, 2021). Project-based learning allows students to begin their learning experience by reading various sources of information and finding a problem, then designing a project and presenting a product as a solution to the problem.

Project-based learning involves students in determining project designs so that they gain meaningful knowledge and experience (Sonia et al., 2013). Project-based learning also helps students gain a better understanding of concepts, experience in designing product designs, and problem-solving skills (Fortus et al., 2004). Students conduct experiments in solving problems through a cognitive conflict process until a solution is obtained that can answer society's needs (Dym, C. L. & Little, 2002). To solve problems, students study the scope and context of the problem, explore various solutions, anticipate further problems, develop products and test their validity.

Technology-based PjBL model innovation is believed to provide more optimal results to achieve learning goals (Wijayanti et al., 2016). Innovation in learning models with technology produces more productive learning (Demchenko et al., 2021). Project-based learning integrated with ICT has been widely used. Apart from the learning process, forms of integration also include media, teaching materials and learning tools. The implementation of project-based learning that is integrated with ICT provides many benefits, one of which is being able to train students to decide on solutions to problems in the form of products after collecting information from various sources. With information technology, teachers can link learning with other fields of study (Rothe, 2015).

One way to strengthen project-based learning is to integrate information and communication technology (ICT), such as Geogebra software, which can help students understand mathematical concepts visually. Geogebra is an effective tool in describing and visualizing mathematical concepts (Sari, Ardana, & Suweken, 2021). For this reason,

according to Pamungkas & Sudihartinih (2021), students need Geogebra as a learning tool in Analytical Geometry lectures. Geogebra makes it easy for students to understand a concept and to solve mathematical problems, and can clarify the meaning of a concept in mathematics from abstract to concrete, besides that it can be used to see problems from other points of view such as visual (Misron, et al., 2020., & Yerizon et al., 2022). Using GeoGebra can stimulate students to be able to express their mathematical ideas carefully and precisely, so that students' critical thinking is developed and learning activities become more lively, active and effective.

Several studies show that using Geogebra in learning geometry can improve student performance and help them understand mathematical concepts better. Research conducted by (Seloraji & Eu, 2017) shows that the use of GeoGebra can improve student performance in geometric studies. The application of GeoGebra in the geometry teaching and learning process will help students to explore concepts in more detail and help them to build and develop their geometry knowledge (Jelatu, Sariyasa, & Ardana, 2018; Öçal, 2017).

Based on these considerations, this research aims to develop a project-based Student Worksheet that uses Geogebra as a tool. This research is important to carry out because this GeoGebra-assisted project-based Student Worksheet can not only help and train students in finding their own understanding of mathematical concepts and procedures, students can also develop and construct their mathematical knowledge and abilities by utilizing technology.

▪ METHOD

Participant

This research was carried out in the even semester of the 2022/2023 academic year. The subjects in this research were two mathematics education lecturers as material experts, one lecturer as a practitioner and 14 students of the 6th semester mathematics education study program.

Research Design and Procedures

This research is development research (Research and Development - R&D) which uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model (Sugiyono, 2015). Analysis, which focuses on analyzing student worksheet needs including curriculum analysis and analysis of student characteristics. Design, which focuses on the activity of designing project-based student worksheet drafts using Geogebra. Development, at this stage validation is carried out on the draft student worksheet that has been designed and revisions are made based on suggestions given by the validator. Implementation, conducting trials on products that have been designed. Evaluation, distributing practicality questionnaires to analytical geometry students and lecturers, then revising the product based on suggestions obtained from the practicality questionnaire.

Then carry out tests to test the effectiveness of the product being developed. The development of student worksheets is carried out in several stages until they meet the criteria of validity, practicality and effectiveness (Akker, 1999). The research was carried out in the even semester of the 2022/2023 academic year.

Instrument

The instruments used in this research consisted of validation questionnaires, practicality questionnaires, and learning outcomes tests. Validation sheets are used to measure the level of validity of the student worksheets developed, student response questionnaires and practitioner lecturer responses to measure the level of practicality of the product being developed, and learning outcome tests to measure the level of product effectiveness (pretest-posttest). The learning outcomes test is in the form of essay questions totaling 5 questions. The instruments used in this research were developed independently based on material created in the Student Worksheet. The results of validation calculations by experts and product users are used as a basis for revising the products being developed.

Analisis Data

Data collection and analysis techniques were carried out by providing validity and practicality questionnaires. The validation and practicality assessment uses a Likert scale with scores of 1, 2, 3, and 4. The results of the percentage of validity and practicality are then interpreted according to the criteria as in Table 1 (Sugandi, Linda, & Bernard, 2020).

Table 1. Interpretation of validity and practicality

Percentage	Criteria
0 – 20	Very invalid/very impractical
21 – 40	Less valid/less practical
41 – 60	Fairly valid/Fairly practical
61 – 80	Valid/practical
81 - 100	Very valid/Very practical

To determine the effectiveness of the student worksheet being developed, a pretest was carried out before being given treatment and a posttest after being given treatment, so that accurate data was obtained (Sugiyono, 2019). Analysis of the pretest and posttest results was carried out using the gain score. The results of the gain score calculation where the n-gain criteria are interpreted based on table 3. Based on the gain score criteria, the game is said to be effective if the student's learning results obtain an n-gain score > 0.3 with medium or high criteria.

Table 3. Gain score criteria

n-gain	**Category**
$(g) > 0.7$	High
$0{,}3 < (g) \leq 0.7$	Middle
$(g) \leq 0.3$	Low

▪ RESULT AND DISSCUSSION

This research produces a product in the form of a project-based Student Worksheet using Geogebra. The results of this research based on the ADDIE stages are:

Analysis

The activities carried out at this stage are: First, analyze the needs of student worksheets. Observations were carried out on students in the 6th semester of the

mathematics education study program at Bung Hatta University, and the results showed that in the learning process, students were still unable to construct their own knowledge. Students are more likely to wait for explanations of material from lecturers in class. The learning carried out also does not direct students to be able to discover mathematical concepts for themselves. Even though students already have knowledge about developing technology, they have not fully utilized it in the learning process. There are many ways to utilize technology in learning, especially in mathematics subjects. One effective way is to use software, such as Geogebra. Students have the opportunity to use the Geogebra tool to help them visualize the lesson material better, which in turn can help them understand the mathematical concepts being taught. As research by Yorganci (2018) states that the use of Geogebra in learning can improve students' visualization abilities and Geogebra is also easy to use and is well known by many people.

Therefore, an activity is needed that can provide opportunities for students to be more active in building their own knowledge using developing technology. This activity is designed in the form of a worksheet containing projects that will be done together in groups using Geogebra. By completing this project, it is hoped that students will be more independent in building their own knowledge.

Second, Curriculum Analysis. In accordance with the curriculum implemented in the Bung Hatta University mathematics education study program, namely the independent curriculum, the recommended learning model is a problem and project based learning model. Therefore, using project-based student worksheets is the right approach, with the aim of allowing students to test their abilities in solving various mathematical problems given. The independent curriculum also supports the use of technology in the learning process, such as the use of Geogebra software, which is expected to increase student motivation in completing their project assignments. This is in line with research conducted by Daher (2021) which states that using geogebra in learning can increase student motivation in learning.

Third, analyze the characteristics of students. From the analysis of student characteristics, it can be seen that students are very interested in learning using technology. Students are also more motivated in studying and completing assignments given by lecturers, especially when learning using Geogebra software. This was also expressed by Wahyuni, et al (2022) that students feel happy learning and are interested in learning using technology, because it is in accordance with current developments. Therefore, real efforts are needed from lecturers to actively utilize technology in the learning process, so that students can construct their own knowledge, and students can study independently at home by utilizing this software. One of them is the development of project-based Student Worksheets with the help of Geogebra.

Design

This research produces a project-based Student Worksheet which contains project assignments that will be carried out by students using geogebra on circle material. The initial product design / draft 1 of this Student Worksheet is in accordance with the framework of the results of the analysis of the problems to be solved and is designed to guide, direct, guide students in finding concepts and using these concepts to solve problems with project-based learning with the help of Geogebra. This is in accordance with constructivism theory so that learning can be more meaningful and students can

better understand the concepts they are studying (Suparlan, 2019). The following is an example of a student worksheet design:

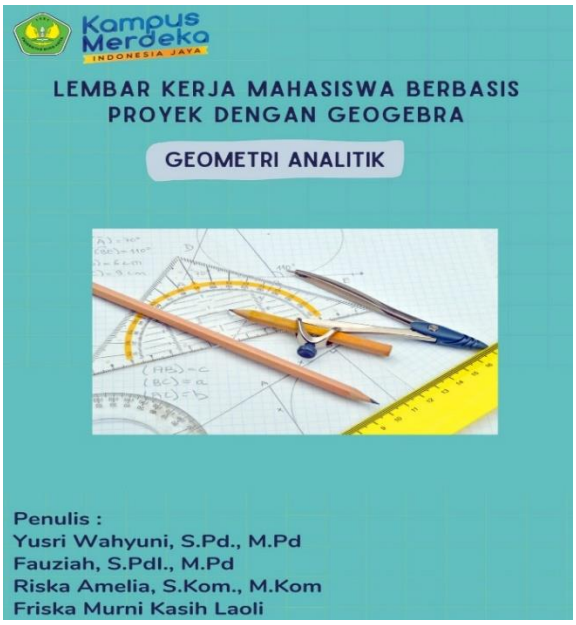

Figure 1. Cover of project based student worksheet

Development

At the level ofdevelop Validation is carried out on the module that has been designed, by giving the student worksheet product to the validator, the validator provides an assessment available on the validation sheet, the student worksheet is revised (if any), validated again by the validator, after obtaining valid quality it is then tested on learning activities .

Validation of this design was carried out by two lecturers at the Bung Hatta University Mathematics Education Study Program. Each validator provides assessments, suggestions and comments on the student worksheets that the authors develop to see the suitability of the product as material for student assignments. Project-based Student Worksheet validation test results obtained by analyzing the calculation of the average value as a result of the validation analysis of the project-based Student Worksheet as shown in Table 4

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Worksheet validation test results obtained by analyzing the calculation of the average value as a result of the validation analysis of the project-based Student Worksheet as shown in Table 4.

Table 4. Validity results

No	Aspects	Average	Category
1	Content eligibility	0.84	Very valid
2	Language	0.84	Very valid
3	Layout	0.83	Very valid
4	Graphics	0.76	Valid
	Average	0.82	Very valid

Based on Table 1, it can be explained that the project-based Student Worksheet has been revised according to the validator team's input. In general, the Student Worksheets developed have very valid criteria and are suitable for testing.

Implementation

Trial Implementation was carried out on a limited basis on 14 semester 6 Bung Hatta University mathematics education students. Researchers as mathematics lecturers carry out learning based on products that have been developed. Other researchers serve as observers and record everything on an observation sheet that can be used to improve the product.

Evaluation

After the learning process is complete, students are given a questionnaire to determine the level of practicality of the product being developed. The results of the product practicality questionnaire can be seen in table 5

Table 5. Practicality results

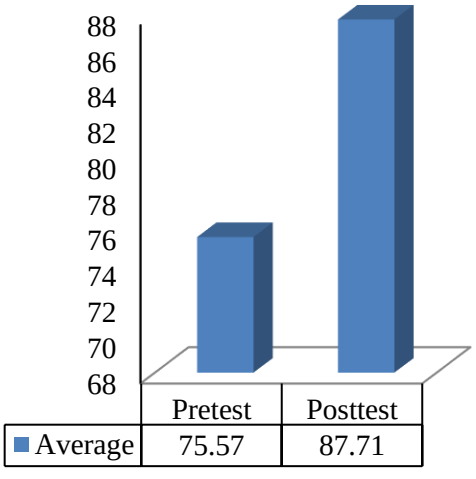
Aspects	Average score	Category
Usefulness	82%	Very practical
Easy-of-use	78%	Practical
Novelty	80%	Practical
Attractiveness	85%	Very practical
Average	81.25%	Very practical

From the results of the questionnaire data, it can be concluded that as many as 81.25% of students considered that the student worksheet developed was very practical, without any obstacles identified by students in its use. In terms of benefits, this project-based student worksheet has proven to be very useful in helping students understand mathematical concepts independently, and the use of Geogebra in completing projects has improved students' visualization skills, so they can better understand the material being taught.

From the perspective of ease of use, this student worksheet is categorized as easy for students to use with an average response score of 82%. This means that this student worksheet has a systematic structure in conveying instructions related to the project that

the student will be working on. The guidelines for using student worksheets are easy to understand, the problems given are clear and simple, the language used is also easy to understand, and the size and type of letters are comfortable and easy to read. In the context of innovation, project-based student worksheets integrate project tasks that must be completed by students in groups with the use of technology, namely the Geogebra application. Learning using technology can raise students' enthusiasm for learning because it is in line with current developments. The projects that have been completed by the students will later be published via YouTube. By using this student worksheet, students are more motivated to complete the project assignments contained in the student worksheet. In terms of attractiveness, student worksheets are categorized as attractive by students with an average response score reaching 85%. This shows that the student worksheet developed has the ability to increase student interest and motivation in completing the project assignments contained in the student worksheet. Even though the student worksheet developed still requires revision, based on the analysis of validation results and analysis of practicality test questionnaire results, it can be concluded that the student worksheet developed is of good quality and can be used as a guide for students in completing the given project assignments.

To find out the effectiveness of the student worksheet developed, it can be seen from the student learning outcomes. At the beginning of the meeting, a pretest was carried out to determine the students' initial abilities before learning using the student worksheets that were developed. After carrying out the pretest, learning was carried out using Student Worksheets which were developed using Geogebra. The next step after implementing learning using the Student Worksheet developed is carrying out a posttest. The posttest was carried out with the aim of finding out the final knowledge of student worksheet users. The processing time and questions given are the same as the pretest carried out before learning using student worksheets. The average results of student pretest and posttest scores can be seen in Figure 2. From the data obtained, it can be concluded that student worksheets are effectively used in the learning process by students with an average n-gain score of 0.50.



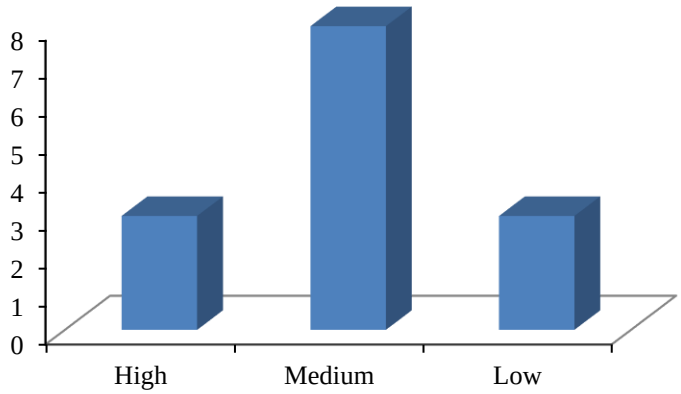


Figure 3. N-gain score

▪ CONCLUSION

Based on the research results, it is known that project-based student worksheets that use Geogebra as a tool have valid criteria with a percentage of 82%. Practical to use with a percentage of 81.25% and effective to use with a percentage of 81%. So it can be concluded that the student worksheet developed is valid, practical and effective to use. Recommendations for further research, it is necessary to carry out further research with a wider population and sample, because this research was carried out only with a limited number of samples and population. This student worksheet can be used as a tool in learning analytical geometry by students. Geogebra technology helps students to better visualize mathematical concepts, increases their interest in learning, and helps them solve mathematical problems independently and in groups.

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