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Effectiveness of GeoGebra-Based Interactive Multimedia to Improve Mathematical Concept Understanding Ability

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Abstract. *The ability to understand mathematical concepts is very important for students to develop because it can give rise to other mathematical abilities. Therefore, efforts are made to develop it using GeoGebra-based interactive multimedia. This research aims to find out how effective GeoGebra-based interactive multimedia is in improving understanding of mathematical concepts. The method in this research is research and development (RnD) with reference to the ADDIE steps. The subjects in this research were 7th-grade junior high school students. The results of this research show that learning GeoGebra-based interactive multimedia on triangles and quadrilaterals is effective in improving the ability to understand mathematical concepts. These results can be seen from the significant regression value, namely the Sig value. 0.007 < 0.05, so it can be said that there is an influence between the ability to understand mathematical concepts of students who are taught using GeoGebra-based interactive multimedia learning in the experimental class is better than the ability to understand mathematical concepts of students who are taught with conventional learning (PBL) in the control class.*

Keywords: *Multimedia, GeoGebra, Concept mathematical*

INTRODUCTION

Mathematics grows and develops rapidly in all places and has experienced rapid development in the world of mathematics (Soebagyo et al., 2021). Mathematics is an important science that must be learned because it plays a role in other sciences. Therefore, math is taught in all public and private schools. Branches of mathematics include algebra, geometry, and calculus. At the same time, geometry materials include lines, angles, spaces, and flat shapes. These materials need to be applied in everyday life. Mathematics learning is carried out contextually so that students gain new experiences and insights.

Concept understanding is needed to develop critical and systematic thinking skills, reasoning skills, and an objective and open attitude in dealing with everyday

life problems (Anggraeni et al., 2021). However, there are still many students who have difficulty understanding mathematical concepts. When students are faced with problems that are slightly different from the example problems explained by the teacher, students begin to be overwhelmed to solve them (Silalahi et al., 2023). One of the reasons that students are not able to master the topics in mathematics well is because students lack understanding in solving the given math problems, so the ability to understand concepts is needed, which is an important aspect of learning mathematics. According to Rahmawati & Roesdiana (2022), the problem that occurs when in mathematics learning activities is that students do not understand the concept of the material being taught because students are only encouraged to memorize mathematical formulas without understanding the concepts that occur in the material

Efforts to improve concept understanding skills are by using multimedia when learning. According to Mukarramah et al. (2022), the conclusion is that learning mathematics with the use of GeoGebra software applications can improve students' ability to understand mathematical concepts. According to Manurung (2021), one step to stimulate accelerated student understanding of the material taught is by using multimedia. Multimedia is a combination of various elements: text, sound, images, animation, audio, and video. One of the interactive learning media that can be used to improve concept understanding ability is GeoGebra-based learning media. GeoGebra is an application that was developed into teaching materials and is easily accessible to anyone (Tamami, 2021). GeoGebra is dynamic math software that can be used as a tool for learning mathematics (Yanti et al., 2019). According to Setiawan et al. (2023), interactive learning media using GeoGebra software is feasible to use as learning media. GeoGebra software can be used as a learning medium, especially in the field of geometry.

RESEARCH METHODS

The type of *research* used in this study is Research and Development (R&D), which is oriented towards product development and testing the effectiveness of these products. This research method uses the ADDIE model development research

design, which consists of five stages, namely analysis, design, development, Implementation, and Evaluation, to develop GeoGebra-based interactive multimedia on quadrilateral and triangle material. The research was carried out at SMP N 2 Sayung (Sayung 1 State Junior High School), where 2 samples were taken, namely class VII F as the control class and class VII G as the experimental class. This study uses a questionnaire instrument, namely a student assessment sheet, while the test is a description question sheet. In this study, data analysis was needed, namely the initial data analysis using pretest scores and the final data analysis using posttest scores.

RESULTS AND DISCUSSION

The development of GeoGebra-based interactive multimedia on the triangle and quadrilateral material was carried out at SMP Negeri 2 Sayung in accordance with development procedures that refer to the ADDIE model, namely based on the stages of analysis, design, product development, implementation, and evaluation.

The analysis stage is carried out by observing teaching materials and media that have been used as learning resources in the learning process. Learning resources are only guided by one book obtained from the government. So that other learning resources are needed to increase student knowledge. Therefore, researchers developed an interactive math learning multimedia and were able to motivate students in the learning process. Researchers chose GeoGebra and Canva software with the PBL model so that students are motivated in the learning process and can improve their ability to understand mathematical concepts.

After the analysis stage, the next is the design stage. This stage includes preparing the structural framework of the GeoGebra-based interactive multimedia to be created; researchers analyze the material displayed, analyze the display design, determine the evaluation questions, and design videos. Furthermore, determining the instrument used is a type of questionnaire given to media experts, material experts, and students who are the subject of research. The validation sheet for media experts and material experts is in the form of a questionnaire using a five scale whose assessment scale criteria strongly agree given a score of 5, you agree

given a score of 4, neutral given a score of 3, disagree given a score of 2, and strongly disagree given a score of 1. The instrument for research subjects is an evaluation test and a student response questionnaire.

After the design stage, then do the development stage. At this stage of development, it produces interactive multimedia based on GeoGebra on triangle and quadrilateral material through the pre-research stage. The pre-research in question is to validate the product to 3 media experts and 3 material experts.

The results of the validation of the three media experts based on the eligibility criteria obtained an average of 88.2%. From the results of the media expert validation, it can be interpreted that GeoGebra-based interactive multimedia is very good and feasible to use with revisions according to suggestions from media experts. This media validation indicator consists of 4 aspects, namely: general aspects, presentation aspects, language aspects, and media graphics aspects. Details of the results of media validation for each aspect can be described in the following bar chart.

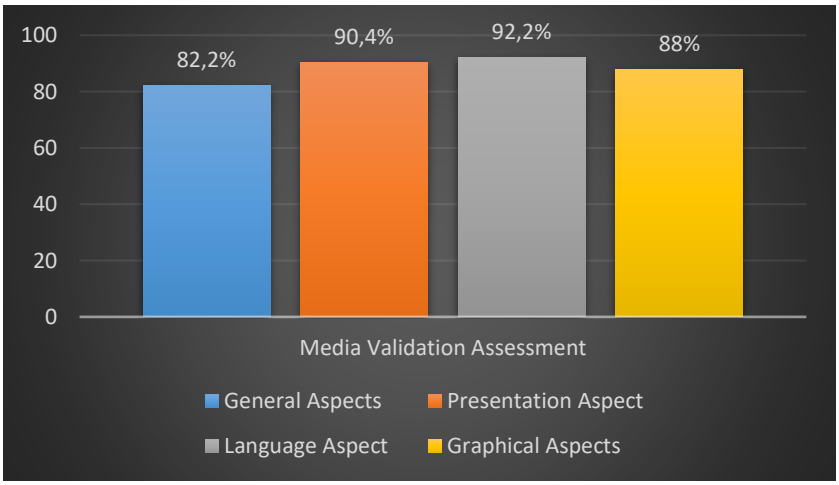

Diagram 1. of Media Expert Validation Results Details

Next is validation by material experts. The results of the validation of the three material experts based on the eligibility criteria obtained an average of 88%. From the results of the material expert validation, it can be interpreted that these GeoGebra-based interactive multimedia is in the very good category (feasible) to use even though revisions need to be made according to suggestions from material

experts. This material validation indicator consists of 3 aspects, namely, general aspects, material substance aspects, and learning design. Details of the material validation results for each aspect can be described in the following bar chart.

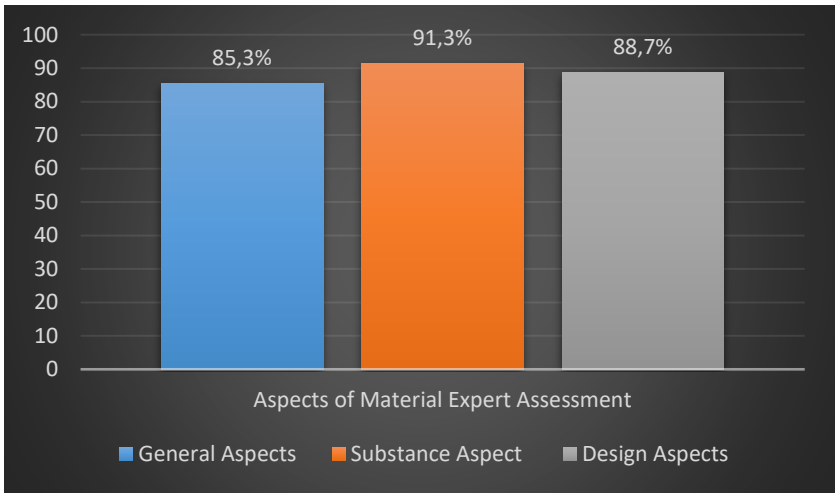

Diagram 2. Diagram of Material Expert Validation Results

The validation results were used as a draft and then edited and revised so that the next stage could be carried out, namely the implementation stage. At the implementation stage, this stage is the instrument trial. Evaluation test instruments need to be tested to determine the validity, reliability, level of difficulty, and differentiation of the questions. This trial was conducted to determine the feasibility of the evaluation question. After discussing with the mathematics teacher at SMPN 2 Sayung, the researcher chose class IX-A as the test class. In the test questions, 10 essay questions will be tested.

The results of the test analysis on 33 students of class IX-A obtained valid questions, as many as 10 questions. Furthermore, the calculation of the level of difficulty is known to be 1 difficult category question and 9 easy category questions. Then, from the analysis of the differentiating power of the question, it is known that 10 questions have good differentiating power.

After testing the instrument, the researcher conducted a product usage test. At the product use test stage, researchers chose class VII-G with 33 students as the experimental class and class VII-F with 32 students as the control class. The initial

analysis of the two classes was taken from the pre-test scores of students' mathematical concept understanding abilities.

At the evaluation stage, researchers analyzed the initial and final data. For the normality test in this study, the Lilliefors test was used. The normality test of the initial data was carried out using spps 2.0 software. Based on the significance value in the test of normality table, the significance value in the control class is 0.797, and in the experimental class is 0.407. Because 0.797> 0.05 and 0.407> 0.05, Ho is accepted. The conclusion is that the samples in the experimental class and control class come from a normally distributed population. To test the homogeneity of the two classes using the Bartlett test. Based on the results of calculations that have been carried out using SPSS in the test of homogeneity of variances table. Based on the two obtained significance values (probability), the value of Sig.=0.084, then Sig.=0.084> 0.05, so that the H_0 hypothesis is accepted. The conclusion is that H_0 is accepted, so the two variances of the population in the Experiment class and Control class are the same (homogeneous data).

The final data normality test was calculated using spss 2.3. Based on the significance value in the test of normality table, the significance value in the control class is 0.288, and in the experimental class is 0.361. Because 0.288> 0.05 and 0.361> 0.05, then H_0 is accepted. The conclusion means that the samples in the experimental class and control class come from a normally distributed population. The final data Homogeneity test is calculated using spss 2.3. Based on the results of calculations that have been carried out using SPSS, in the test of homogeneity of variances table. Based on the two obtained significance (probability) values, Sig.=0.547, then Sig.=0.547> 0.05 so that the H_0 hypothesis is accepted. The conclusion is that H_0 is accepted, so the two variances of the population in the Experiment class and Control class are the same (homogeneous data).

Based on the results of output using IBM SPSS 23, the average N-Gain Score for the experimental class was calculated at 0.4883, including in the medium category. In the experimental class, the N-Gain Score ranged from the lowest 0.21 to the highest 0.82. Meanwhile, the average N-Gain Score for the control class is 0.4633, which is included in the moderate category, making it one of the low scores.

The N-Gain scores in the control class ranged from a low of 0.25 to a high of 0.80. The N-Gain value provides evidence that the use of an interactive multimedia learning model based on GeoGebra can improve the ability to understand mathematical concepts on quadrilateral and triangle material.

After the product usage trial, the researcher gave a questionnaire of student responses to learning to 33 experimental class students then students filled out an assessment questionnaire of the product. The assessment questionnaire contains 30 questions, with each question having a maximum value of 5 and a minimum value of 1. The maximum percentage will be achieved by 100%. The results of student responses to learning with GeoGebra-based interactive multimedia are very good. Many of the students feel very happy in learning and better understand the material. Among the 33 children who were respondents, the highest response value was 95.3%, the lowest response value was 70.7%, and the average student response value was 95%. This average was in the very good category. Details of the results of student responses for each aspect can be depicted in the following bar chart.

It can be concluded that learning by using GeoGebra-based interactive multimedia with a Problem-Based Learning *(*PBL*)* model is better than conventional learning at SMPN 2 Sayung grade VII on triangles and quadrilaterals. These results show that learning using GeoGebra-based interactive multimedia can improve students' mathematical concept understanding abilities in triangle and quadrilateral material.

These results are in accordance with research by Anggraeni et al. (2021), which states that the development of GeoGebra-based learning media for quadrilateral and triangle material for grade 7 SMP Datok Sulaiman Palopo has met the criteria of validity, practicality, and effectiveness. This result is also supported by research by Yanti et al. (2019), which states that there is a significant difference in increasing the understanding of mathematical concepts of students who apply a scientific approach assisted by GeoGebra and who use ordinary learning. While research by (Mukarramah et al., 2022) stated the results of research entitled the effect of using GeoGebra software on students' concept understanding ability and mathematical problem solving, illustrating that there is a significant positive effect

between the use of GeoGebra software on students' mathematical concept understanding ability.

This research was conducted at SMP Negeri 2 Sayung, using GeoGebra-based interactive multimedia on the triangle and quadrilateral material carried out in reference to the ADDIE model, which is based on the stages of analysis, design, product development, implementation, and evaluation.

1) Analysis Stage

The analysis stage is carried out through observation of subject matter and media used as learning resources during the learning process. Educational resources only depend on one book purchased by the government. Additional learning resources are needed to increase students' knowledge. Therefore, the researcher created an interactive multimedia that can keep students motivated as they learn. The researchers decided to use GeoGebra and Canva software, which functions as a PBL model, to keep students motivated during the learning process. They also wanted to improve students' understanding of mathematical concepts. With the help of GeoGebra, learning with the AIR model can improve students' mathematical understanding (Sonia et al., 2023). According to Astri et al. (2022), one of them is the use of teaching materials, namely learning media that is less than the maximum; especially in learning mathematics, students lack understanding of mathematical concepts.

2) Design stage

After analysis, the design came. This stage includes creating a skeleton structure of GeoGebra-based interactive multimedia. In this process, researchers analyze the content displayed, analyze the display design, determine the evaluation questions, and create videos. Furthermore, the instrument used is a type of questionnaire given to students who are the subject of research, media experts, and material experts. The validation tool for media experts and material experts is a questionnaire with a scale of five assessment criteria, with strongly agree given a score of 5, agree given a score of 4, neutral given a score of 3, disagree given a score of 2, and strongly disagree given a score of 1. The instruments for research subjects are evaluation tests and

student response questionnaires. At the Design stage by research Iswara & Cahdriyana (2022) the design of combining various media combined with GeoGebra to help students visualize that there are HTML5 products. At the design stage of research, Apriyanto & Hilmi (2019) designed material content and *storyboards* by combining materials such as images, sound, and text. The design stage by Farhatin et al. (2020)makes the design of teaching materials to be developed by creating a format from the beginning of learning to the end of learning.

3) Development stage

After the design stage, then the development stage. At this development stage, it produced interactive multimedia based on GeoGebra in triangle and quadrilateral materials through the pre-research stage. The pre-research in question consists of validating the product for 3 media experts and 3 material experts.

According to the results of the validation of media experts, it can be interpreted that interactive multimedia based on GeoGebra is very good and feasible to use with revisions according to the suggestions of media experts. Meanwhile, according to the results of the validation of material experts, it can be interpreted that this interactive multimedia based on GeoGebra is in a very good category (feasible) even if it has to be revised according to the equipment expert's suggestions.

The validation results are used as a draft and then modified and revised so that the next phase, the implementation phase, can be carried out. In the research development stage by Pratama et al. (2023), this stage has been carried out in the preparation and design of storyboards with the software to be used, and the results are in the form of prototype 1 or multimedia that is not yet suitable for use. This research is at the development stage by Aspriyani & Suzana (2020); at this stage revisions are made from media experts and material experts to improve the e-module before being tested on students. At the development stage of research by Septian et al. (2021), this stage revises and

improves the product from the suggestions of media experts and material experts before publication.

4) Implementation Stage

This phase is the instrument test in the implementation phase. The evaluation test question tools should be tested to find validity, reliability, difficulty level, and differentiating power. This test is conducted to determine the feasibility of the evaluation problem. After discussing with the math teacher of SMPN 2 Sayung, the researcher chose Klasse IX-A as the test lesson. Ten essays were tested in the test questions. After testing the instrument, the researcher conducted a product use test. At the product use trial stage, the researcher chose class VII-G, totaling 33 students, as the experimental class and class VII-F, totaling 32 students, as the control class. The initial analysis of the two classes was taken from the pre-test scores of students' mathematical concept understanding abilities. This implementation stage is in line with research by Zaharah et al. (2021), where the implementation stage is carried out or applied in real classroom situations with real teaching using multimedia content for evidence-based mathematics learning. This stage is also in line with the research of Huda et al. (2024) state that in the implementation stage, media products that have been finished and have been validated are then tested on students through the learning process. This stage is in line with the research of Shafa & Yunianta (2022) that this implementation stage, the media that has been created and developed has been tested on students by carrying out pre-tests and post-tests

5) Evaluation Stage

At the evaluation stage, researchers analyzed the initial and final data. For the normality test in this study, the Lilliefors test was used. Based on the significance value in the test of normality table, the significance value in the control class is 0.797, and in the experimental class is 0.407. Because 0.797> 0.05 and 0.407> 0.05, then H_0 is accepted. The conclusion is that the samples in the experimental class and control class come from a normally distributed population. Testing the homogeneity of the two classes used Bartlett's test.

Based on the results of calculations carried out with SPSS in the variance homogeneity test table. Based on the two significance values (probability values) obtained, the Sig = 0.084 value is obtained, then Sig = 0.084> 0.05, so the H_0 hypothesis is accepted. In conclusion, H_0 is accepted so that both population variants in the experimental class and control class are the same (homogeneous data).

For the normality test, the final data was calculated using SPSS 2.3. Based on the significance value listed in the normality test table, the significance value obtained in the control class is 0.288, and in the experimental class is 0.361. Because 0.288 > 0.05 and 0.361 > 0.05, H_0 is accepted. The conclusion means that the samples of the experimental class and control class come from a normally distributed population. The final test of data homogeneity was calculated using SPSS 2.3. Based on the results of calculations carried out with SPSS in the variance homogeneity test table. Based on the two significance values (probability) obtained Sig = 0.547, then Sig = 0.547> 0.05, the H_0 hypothesis is accepted. The conclusion is that H_0 is accepted, so the two population variants in the Experiment class and Control class are the same (homogeneous data).

It can be concluded that learning with GeoGebra-based interactive multimedia using the Problem-Based Learning (PBL) model is better than conventional learning at SMPN 2 Sayung Class VII in the subject of Triangles and Quadrilaterals. This result shows that learning with GeoGebra-based interactive multimedia can improve students' ability to understand the mathematical concepts of triangles and quadrangles.

These results are in accordance with research by Anggraeni et al. (2021), which states that the development of GeoGebra-based learning media for quadrilateral and triangle material for grade 7 SMP Datok Sulaiman Palopo has met the criteria of validity, practicality, and effectiveness. These results are also in research Raharjo et al. (2023) concluded that the development of learning media based on GeoGebra software on cubes to develop students' spatial abilities has met the criteria of validity, practicality, and effectiveness. It is also in research I.G.

Arjana & I.W. Suastra (2022) concluded that the development of GeoGebra-based interactive simulations in supporting the implementation of basic mechanics-based physics lectures has met the criteria of validity, practicality, and effectiveness. It is also in research Raharjo et al. (2023) concluded that the development of GeoGebra software-based learning media on cubes to develop students' spatial abilities has met the criteria of validity, practicality, and effectiveness. This result is in research Wasi (2022) concluded that the development of interactive math media assisted by GeoGebra software on geometry transformation material class XI SMA. This result is in research by Scesa et al., (2024) concluded that the development of android-based E-BARET multimedia for grade X high school students has met the criteria of validity, practicality, and effectiveness. This result is also supported by research by Yanti et al. (2019), which states that there are significant differences in increasing the understanding of mathematical concepts of students who apply a scientific approach assisted by GeoGebra and who use ordinary learning. According to research, Rohim et al. (2023) concluded that the results of the development of learning devices using GeoGebra on geometry transformation material are effective.

CONCLUSION

Learning with GeoGebra-based interactive multimedia on triangle and quadrilateral material is effective for improving the ability to understand mathematical concepts of grade 7 students. This result is evidenced by the results of significant regression values so that there is an influence between the ability to understand the mathematical concepts of students taught with GeoGebra-based interactive multimedia learning in the experimental class better than the ability to understand the mathematical concepts of students taught with conventional learning (PBL) in the control class.

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