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The Effectiveness of Comic Illustrated Augmented Reality Learning Media to Improve Mathematical Problem-Solving Ability

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Abstrak

Pemecahan masalah merupakan interaksi antara pengetahuan yang menggunakan proses berpikir kognitif dan afektif. Namun saat ini hasil PISA menunjukkan kemampuan pemecahan masalah matematis siswa di Indonesia masih rendah. Salah satu pembelajaran baru yang saat ini sedang dikembangkan adalah pemanfaatan teknologi augmented reality. Tujuan penelitian ini adalah mengembangkan media pembelajaran augmented reality bergambar komik untuk meningkatkan kemampuan pemecahan masalah matematis. Jenis penelitian yang digunakan adalah penelitian R&D (Research & Development). Model ADDIE yang digunakan dalam penelitian ini terdiri dari analisis, desain, pengembangan, implementasi, dan evaluasi. Data yang dianalisis diperoleh dari pretest dan postes. Kelas eksperimen berjumlah 31 siswa dan kelas kontrol berjumlah 30 siswa. Hasil uji hipotesis beda rata-rata data keefektifan menghasilkan ***t-obs*** *= 9,26 dengan daerah kritis (t> 1, 6973) sehingga keputusan pengujiannya adalah H0 ditolak. Jadi, dapat disimpulkan bahwa media pembelajaran augmented reality bergambar komik efektif meningkatkan kemampuan pemecahan masalah siswa sekolah menengah.*

Kata kunci: *Media Pembelajaran,* Augmented Reality*, Komik, Matematika, Efektifitas*

Abstract

Problem solving is an interaction between knowledge that uses cognitive and affective thinking processes. However, currently the PISA results show that students' mathematical problem-solving abilities in Indonesia are still low. One of the new lessons that is currently being developed is the use of augmented reality technology. The aim of this research is to develop comic illustrated augmented reality learning media to improve mathematical problem-solving abilities. The type of research used is R & D (Research & Development) research. The ADDIE model used in this research consists of analysis, design, development, implementation, and evaluation. The data analysed were obtained from pretest and post-test. There were 31 students in the experimental class and 30 students in the control class. The results of the mean difference hypothesis test for effectiveness data produced t-obs = 9.26 with a critical area (t>1,6973) so that the test decision was that H0 was rejected. So, it can be concluded that augmented reality learning media with comic illustrations is effective in improving middle school students' problem-solving abilities.

Keywords: Learning Media, Augmented Reality, Comics, Mathematics, Effectiveness

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1. INTRODUCTION

Learning is an activity carried out with the aim of acquiring knowledge, mastering certain competencies and shaping student attitudes. The success of student learning can be seen from the changes that occur in learning outcomes and student behavior. Mathematics is a subject that has an important role in everyday life. Mathematics has an important role in its use, namely to observe, gather information, measure, hypothesize and even predict the results of scientific research (Coles, 2019; Lengnink, 2005; Rohmah et al., 2022). Previous study state that mathematics has become a basic capital for life, especially for solving problems in everyday life (Laurens et al., 2018). Mathematics has been found since the level of elementary education to university. This opinion is in line with mathematics is a field of study that occupies an important role that is taught at all levels of education from elementary school to university (Pendy et al., 2021; Yunita Anindya et al., 2019). This is in line with the

opinion of previous study that mathematics is very necessary because it has substantial applications, especially in the fields of science and technology. Students are required to have some mathematical abilities, especially in the field of mathematics (Dishon & Gilead, 2020; Qurohman et al., 2019).

The National Council of Teachers of Mathematics states five standard mathematical processes consisting of problem solving, reasoning and proof, communication, connections and representation (Murtiyasa & Perwita, 2020). Therefore, one of the basic mathematical abilities that must be mastered by junior high school students is the ability to solve problems. However, in reality The Program for International Student Assessment (PISA) 2018 shows that students' mathematical problem-solving skills in Indonesia are still low. Problem solving is an interaction between knowledge that uses cognitive and affective thinking processes (Ambarita et al., 2018; Sari & Valentino, 2016). This is because problem solving is a means to hone careful, logical, critical, analytical, and creative reasoning. Various efforts and handling have been done to improve the quality of education. Many innovations have been created to have a positive impact on the world of education, such as the use of computers as learning media (Ma'ratusholihah et al., 2019; Putra et al., 2021). Along with the times, not only through computers, even smartphones can be used as learning media. The existence of smartphones is indeed an important highlight in the 21st century. Almost every student in junior high school, high school, vocational school to campus or university is a smartphone user. This is in line with research conducted by previous study based on the results of a smartphone ownership survey among students that 87% of the total students have their own smartphone (Azmi et al., 2016).

The use of smartphones among students is already familiar, almost all students now use smartphones. Using a smartphone can help students learn anywhere and anytime so that learning becomes more efficient. The use of smartphones as learning support has an impact on two things, namely: (1) increasing access to education and (2) encouraging new learning (Jubaerudin et al., 2021; Qodr et al., 2021). One of the new learning that is currently being developed is the use of augmented reality technology on smartphones. Learning media is defined as a tool used by teachers in conveying material to students so that learning becomes more effective and efficient. By using augmented reality learning media, it is expected that the mathematical problem-solving abilities of junior high school students can increase. Augmented Reality is a technology that can display objects in a real environment with the help of a smartphone (Degner et al., 2022; Gavish et al., 2015). As befits an existing artificial virtual game, humans are likened to a virtual world, whereas in augmented reality the environment around us (pictures, objects) is made to look real by adding artificial virtual objects.

The application of augmented reality learning media in the world of education is to help the learning process of students become independent. By using smartphones, augmented reality learning media can increase students' interest in learning because the process of using them will involve all students without exception. This is in line with the opinion of previous study that a fun learning process can produce good learning outcomes (Suryani & Haryono, 2018). As stated by other study that with augmented reality features, application designs become more interesting and varied for teaching mathematics to students (Elmunsyah et al., 2019). Although the use of augmented reality in education is still new, it is growing rapidly.

Mathematical concepts, especially in geometry, are sometimes difficult to understand as required by students to visualize in 3D. Therefore, augmented reality can be used effectively to enhance learning by stimulating students' curiosity. Previous study states that comics are media that convey messages to their readers through an arrangement of images (Alawamleh et al., 2022). Comics are a medium that combines images and text into creative forms that can attract the attention of readers of all ages, especially children. Comic-

illustrated augmented reality learning media in this study is defined as a teaching material that is used as a means of conveying teaching material to students which includes learning activities in a systematic manner by presenting images combined with text and visualizing geometric objects into 3D shapes with the hope of making it easier for students to understand each element of the geometric shape such as lateral lines, planes, sides, and so on and to convey information to the reader in a fun way (Heru, 2018; Rutta et al., 2021). Therefore this study aims to develop comic illustrated augmented reality learning media to improve mathematical problem solving abilities.

2. METHODS

The type of research used is R & D (Research & Development), namely development research as research used to test the efficacy of products on existing products and can also produce products in the field of education. The development model used in this study is the ADDIE development model (Frydenberg & Andone, 2011). The ADDIE model development research whose main stages include: (1) Analysis, At this stage, the main activities what will be done is to analyze the need to develop a new learning model or method and analyze the feasibility and requirements for developing a new learning model or method; (2) Design, the initial activity is setting learning goals, designing teaching and learning activities, designing learning modules, designing learning materials and learning outcomes evaluation tools. In this stage a development conceptual framework is prepared; (3) Development. At this stage, it will contain the product design realization activities carried out at the design stage. Activities carried out include developing product tools, and starting to make products and making instruments to measure product performance; (4) implementation, at this stage the methods and designs that have been developed in a real situation will be implemented in class. During implementation, the designs that have been developed are applied to actual conditions; (5) Evaluation, will be carried out at the end of each lesson. The evaluation results will be used to provide feedback to researchers, then the evaluation results will be revised by researchers.

This research was conducted at SMP Negeri 2 Palangka Raya with a population of class VIII junior high school students and the sample of this study was students of class VIII-5 as many as 31 students in the pyramid-shaped flat sided space learning, then the control class and the experimental class were selected. The experimental class that took part consisted of 31 students and the control class consisted of 30 students. The samples in this trial were two classes selected based on the simple random sampling technique. This research was conducted by covering planning, development, implementation, data processing, and preparation of reports. Students will carry out learning using learning media that has been developed. The type of data collected is quantitative data. The data analyzed were obtained from the initial test (pretest) of students before being given treatment and the final test (posttest) after being given treatment. The research was conducted in 2 meetings. This research was conducted to measure the effectiveness of learning media.

3. RESULTS AND DISCUSSION

Results

The product of this research is comic-illustrated augmented reality learning to improve junior high school students' problem-solving skills. Comics are a learning medium that can increase students' interest in learning. The development of learning media refers to the ADDIE development model, which consists of Analysis, Design, Development, Implementation, and Evaluation. The quality of module development is based on 3 criteria,

namely validity, practicality, and effectiveness. To obtain certain product results, research is used which is a needs analysis and to test the effectiveness of these products so that they can function in the wider community. The resulting learning media has fulfilled the aspects of validity and practicality. ADDIE development process flow is show in Figure 1.

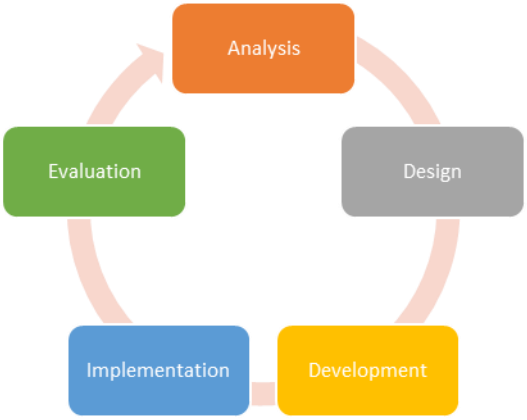

Figure 1. ADDIE Development Process Flow

Analysis Phase

The analysis phase includes an analysis of field studies (learning processes, teaching materials, student abilities), analysis of student needs, and literature studies. This stage obtained some deficiencies or problems in the learning process and teaching materials used and how to overcome these problems. The low ability of students' mathematical problem solving is thought to be caused by the learning process being carried out which is less interesting or boring, the learning process is carried out in the classroom where the teacher explains the learning material directly, gives examples, gives exercises and so on without using media or other teaching materials other than textbooks, besides that the textbooks used were not prepared to improve students' mathematical problem solving abilities so that students' mathematical problem solving abilities became low. Comic-illustrated augmented reality learning media really helps students in understanding learning material because it can motivate students to understand the meaning of the subject matter, they are studying by giving students new learning experiences, which they have never done before, by involving students directly in the learning process in class moreover This learning media is operated using a smartphone.

Design Stage

The design stage includes determining KI, KD and learning indicators, drafting learning media, compiling learning media prototypes, making lesson plans and learning media assessment instruments. Determination of the material is also adjusted to the low scores of students on the flat sided roar material. Determination of KI, KD indicators, preparation of lesson plans based on the existing learning syllabus and discussions with supporting teachers. Making a draft of learning media consists of an opening section containing the title of learning media, menus of basic competencies, achievement indicators, learning objectives, and profiles of learning media developers. The main menu contains “AR Mode” and “Material” to build the flat sides of the pyramid. The Contents section contains learning material sub-chapters, namely the definition of pyramids, pyramid elements, pyramid surface area, and pyramid volume, Explanation of each sub-chapter of comic illustrated material, and AR mode to study pyramid elements in 3D. The closing section contains examples of questions and exercises that students must do at the end of each sub-

chapter of the material they have learned. The presentation of this material is designed with comic illustrations. Furthermore, the making of learning media assessment instruments used in this study is an instrument to measure the validity of learning media (in the form of questionnaires for material experts and media experts), instruments to measure the practicality of learning media (in the form of teacher and student response questionnaires), instruments to measure the effectiveness learning media (in the form of a test of learning outcomes in the form of an essay). The following is a display of comic-illustrated augmented reality learning media, which can be seen in Figure 2.

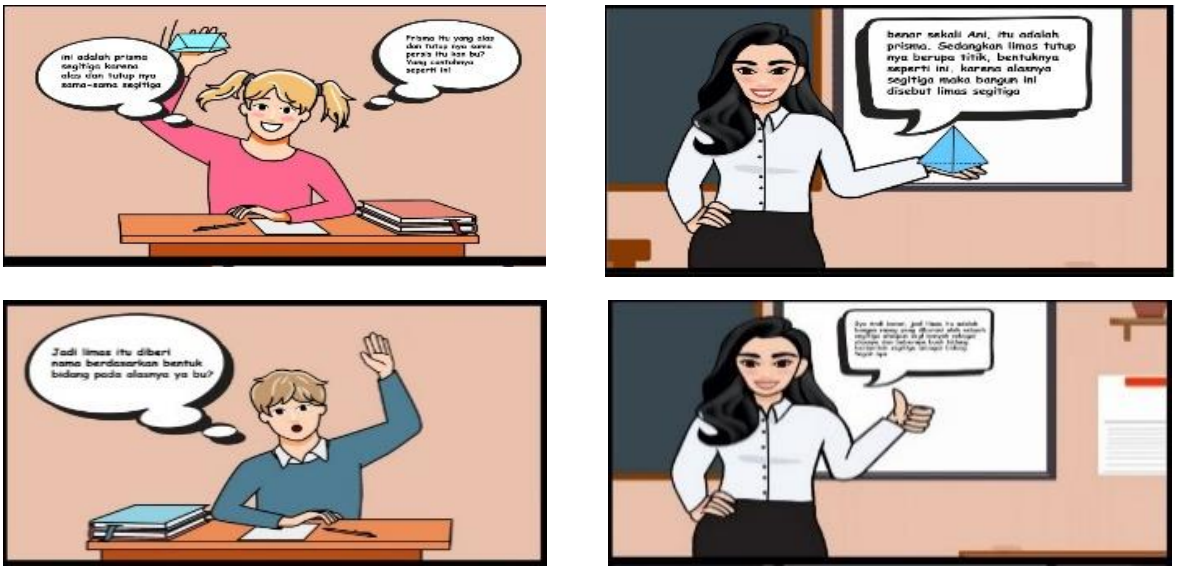

Figure 2. Appearance Comic in Learning Media

In this section there is an explanation of material illustrated as a comic, which contains the definition of a pyramid, pyramid elements, pyramid surface area and pyramid volume. Learning media also includes augmented reality technology, a technology that is relatively new to be developed in Indonesia in particular. Augmented reality media offers a feature that is able to display images of every object scanned through a smartphone camera into 3D, in augmented reality learning media developed by researchers the augmented reality feature can be used in learning to build space on the flat sides of pyramids. Image display on augmented reality media can be seen in Figure 3.

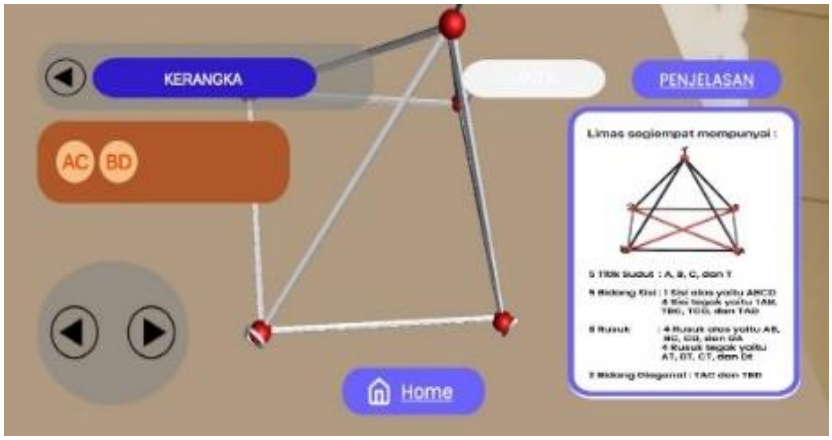

Figure 3. Appearance the use of Augmented Reality Mode

Development Stage

The Development stage includes expert assessment, individual trials, extensive trials and several revisions. The learning media created were validated by several experts and revised by researchers. The final results of validation by material experts were obtained with the "Very Good" criteria. The results of validation by media experts were obtained with the "Good" criteria. Based on the validity indicator, learning media is said to be valid if the average score in the minimum criteria is sufficient for each expert. Therefore, the developed learning media has met the validity indicators, so it can be said that the learning media is valid. After the learning media has been validated and declared valid, then the research instrument is validated in the form of test questions. The validation results for the pretest and posttest questions were 4.0 with the "Very Good" criteria, which means that the pretest and posttest questions were valid and could be tried out. Then individual trials were carried out on 10 students. The purpose of this individual trial is to help readability and understandability of the learning media being developed. Suggestions for input from students were immediately revised by researchers. The direct response from the students was that the learning media was interesting to use because the explanation in the learning media was easy to imagine because it was illustrated using pictures in the form of comics. With a good response from students has an impact on improving student learning outcomes. Further extensive trials were carried out with a sample of 31 students. Extensive trials were carried out in 2 learning meetings and 1 data collection meeting. This extensive trial was carried out to retrieve practical data, namely asking students and teachers to fill out a questionnaire that had been provided. The results of the student response questionnaire obtained 3.43 in the "Practical" category. Then the results of the teacher's response questionnaire obtained 3.59 in the "Practical" category. Based on practicality indicators, instructional media is said to be practical if it meets the minimum criteria of "adequate". Therefore, the learning media meets practicality indicators, so that the learning media is said to be practical.

Implementation Stage

The Implementation phase includes the application of learning media in the classroom after the learning media is declared valid and practical. The application of learning media is carried out at SMP Negeri 2 Palangka Raya Class VIII. Before selecting the two experimental classes and the control class, taking into account the initial learning outcomes of students, it must be balanced. The balance has been tested using the value of the pretest questions on the material for the flat sides of the pyramid. The experimental class carried out the learning process using learning media that had been developed and used lesson plans that had been made by researchers, while the control class carried out the learning process not using the developed learning media, but using mathematics textbooks that had been prepared by the school. The learning process was carried out in 2 meetings to discuss the material and 1 time to take the value (posttest).

Evaluation Stage

The Evaluation stage includes the effectiveness test. Testing the effectiveness of learning media aimed to find out whether the developed learning media can improve students' mathematical problem-solving abilities. Previously, all prerequisite tests had been fulfilled, namely normality and homogeneity tests. Based on the results of the normality test for the experimental class, L-count was 0.119 and L-table was 0.156. In the control class, L-count was 0.132 and L-table was 0.159. The data can be seen in Table 1.

Table 1. Normality Data Test Results

L-count	Class	Critical	Area of Decision Test
Experiment	0.119	$\{ L \mid L > 0.156\}$	H0 is accepted
Control	0.132	$\{ L \mid L > 0.159\}$	H0 is accepted

Based on Table 1, the data on students' mathematics learning outcomes in the experimental and control classes is normally distributed. This means that the sample comes from a normally distributed population. Then a homogeneity test was carried out to find out whether the sample taken was homogeneous or not. The test statistic used is the F test with the help of excel. The results of the pretest data homogeneity test for the experimental class and the control class can be seen in Table 2.

Table 2. Results of Experiment Class and Control Class Homogeneity Data Tests

Data	dk quantifier	dk denominator	A	F count	F table	Test Decision
Postthesis	30	29	0.05	1.308	1,854	H_0 Accepted

Based on the data in Table 2, it can be said that both the experimental class and the control class have homogeneous data. After the requirements have been met, a hypothesis test regarding the two means can be carried out to find out whether the values of the control class and the experimental class are the same or not. From the test results of the two mean values, the results are obtained in Table 3.

Table 3. Balance Data Test Results

Data	t_{obs}	Critical Area	Test Decision
Pretest	0.13207	$\{t \mid t < -2{,}00100 \; atau \; t > 2{,}00100)$	H_0 Accepted

Based on the data in Table 3, it can be said that the values of the experimental class and the control class are balanced. After testing the prerequisites and fulfilling them, hypothesis testing can be carried out. Then the learning process was carried out using augmented reality mathematics learning media for the experimental class, and learning using textbooks for the control class. After learning, the normality test and homogeneity test will be carried out, from the results of the data it is obtained that the normality test is normally distributed, and has homogeneous data. After that, a hypothesis test was carried out to determine the effectiveness of augmented reality mathematics learning media. The statistical test used is the one-tailed t test. The data obtained is shown in Table 4.

Table 4. Results of Hypothesis Testing Data

Data	t_{obs}	critical area	Test Decision
Postest	9,26	$\{ t \mid t > 1.6973\}$	H1 accepted _

Based on the data in Table 4, the values of the experimental class and the control class obtained t_{obs} were 9.26 and DK = $\{ t \mid t > 1.6973\}$. From these results it can be seen that $t_{obs} \in$ DK, then the test decision H_1 is accepted.

Discussion

The advantages of comics when used as teaching materials according to previous study comics contain messages that can be conveyed through stories or fairy tales to students

so that they are easy to understand, teaching materials packaged through storylines will make the subject matter last longer in students' memories and understanding (Rina et al., 2020). Other study stated that augmented reality media is a payment medium that is appropriate for use in learning in schools because of its very high level of interactivity (Huda Bagus et al., 2018).

The results of research conducted by previous study said that the ability to solve problems and think creatively in Indonesian students was relatively low (Sumaryanti, 2020). Smartphones are one of the most reliable online digital devices because of their ease of use. Learning is said to be effective if the learning objectives that have been formulated are successfully applied in learning. Effective learning can be achieved if it is able to provide new experiences, shape students' competencies, and deliver them to the goals to be achieved optimally (Thorndahl & Stentoft, 2020; Turnbull et al., 2019). Other study defines effective learning as a teaching and learning process that is not only focused on the results achieved by students, but how an effective learning process is able to provide good understanding, intelligence, perseverance, opportunity, and quality and can provide changes in behavior that are apply in life (Thorndahl & Stentoft, 2020).

This research produced an augmented reality learning media with comic illustrations in class VIII SMP Negeri 2 Palangka Raya which aimed to improve students' mathematical problem solving abilities. Tests have been carried out to find out whether the augmented reality learning media with comic illustrations is valid, practical and effective. The test results show that comic-illustrated augmented reality learning media is valid, practical and effective to use. In line with the research of previous study learning using comic media in flat sided geometric material is valid, practical, and effective so that it can improve student learning outcomes (Retnawati, 2016). Other research saying that learning with the application of augmented reality as a medium for learning flat sided shapes is valid, practical and effective so that student learning outcomes increase (Sukma et al., 2022). There is also research that is similar to in his research smartphone-based Augmented Reality can be a learning media that brings a lot of progress in the field of education, especially in the digital era as it is now, the presence of an augmented reality learning media innovation will make it easier for students to learn the various materials they receive during learning activities at school (Sugiyarto et al., 2018).

Effective learning can be achieved if it is able to provide new experiences, shape students' competencies, and deliver them to the goals to be achieved optimally. From these results it can be concluded that the average learning outcomes of the experimental class are better than the average learning outcomes of the control class, so that the comic-illustrated augmented reality mathematics learning media fulfills the aspect of effectiveness. After all the stages of the ADDIE development learning media have been carried out and the augmented reality learning media has met the indicators of validity, practicality, and effectiveness. The learning media developed, namely augmented reality learning media with comic illustrations to improve students' mathematical problem solving skills in class VIII pyramid flat sided geometric material, can be disseminated and applied to all schools.

4. CONCLUSION

Testing the effectiveness of learning media aimed to determine whether the developed learning media can improve students' mathematical problem solving abilities. This effectiveness test uses a hypothesis test of the mean difference for paired data between the control class and the experimental class. Previously, all prerequisite tests had been fulfilled, namely the normality and homogeneity tests. The results of the hypothesis test with a different mean for effectiveness data yield 9.26 so that the test decision is that H0 is rejected.

H0 is rejected, meaning that students' problem-solving abilities after using learning media are better than students' problem-solving abilities before using learning media. So it can be concluded that comic-illustrated augmented reality learning media is effective for improving junior high school students' problem solving abilities.

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