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AUGMENTED REALITY: IMPROVEMENT OF CRITICAL THINKING BASED ON STUDENTS' INITIAL MATHEMATICAL ABILITY

Lilis Marina Angraini[1]*, Alzaber[2], Debby Permata Sari[3], Ilham Muhammad[4]

[1,2] Mathematics Education, The Faculty of Teacher Training and Education, Universitas Islam Riau, Riau, Indonesia

[3] Teacher of Mathematics Education at UPT SPNF SKB, Pekanbaru, Riau, Indonesia

[4] Mathematics Education, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

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ABSTRAK

Penelitian ini dilatarbelakangi oleh pentingnya kemampuan berpikir kritis matematis bagi siswa, serta pesatnya perkembangan teknologi informasi di era digital. Penelitian ini secara khusus bertujuan untuk meningkatkan kemampuan berpikir kritis matematis siswa melalui penerapan media pembelajaran berbasis Augmented Reality (AR) dengan unity 3D yang dapat digunakan dalam pembelajaran online dan pembelajaran offline berdasarkan Kemampuan Awal Matematis (KAM). Augmented Reality adalah teknologi yang menggabungkan benda maya tiga dimensi ke dalam lingkungan nyata kemudian memproyeksikan benda-benda maya tersebut secara real-time. Sedangkan kemampuan awal matematis merupakan salah satu faktor yang mempengaruhi pembelajaran matematika, semakin tinggi kemampuan awal matematika seorang siswa maka semakin baik tingkat kemampuan berpikir kritis matematis siswa tersebut. Penelitian ini merupakan penelitian kuantitatif (kuasi eksperimen), sedangkan subjek penelitian adalah siswa kelas VII SMP Negeri 2 Pekanbaru tahun pelajaran 2022/2023 sebanyak 30 siswa yang dipilih secara acak oleh kelas. Penelitian ini dilakukan pada materi bangun datar khususnya segitiga dan segiempat. Metode pengumpulan data yang digunakan adalah tes kemampuan berpikir kritis matematis. Data hasil pengujian diolah dengan uji statistik yang meliputi uji normalitas, uji homogenitas dan uji ANOVA dua arah. Hasil penelitian menunjukkan bahwa peningkatan kemampuan berpikir kritis matematis siswa yang memperoleh pembelajaran menggunakan media augmented reality dengan Unity 3D lebih baik daripada peningkatan kemampuan berpikir kritis matematis siswa yang memperoleh pembelajaran konvensional berdasarkan kemampuan awal matematis siswa.

ABSTRACT

This research is motivated by the importance of mathematical critical thinking skills for students, as well as the rapid development of information technology in the digital era. This study specifically aims to improve students' mathematical critical thinking skills through the application of Augmented Reality (AR)-based learning media with 3D unity that can be used in online learning and offline learning based on Initial Mathematical Ability (IMA). Augmented Reality is a technology that combines three-dimensional virtual objects into a real environment and then projects these virtual objects in real-time. While the initial mathematical ability is one of the factors that influence the learning of mathematics, the higher the initial mathematical ability of a student, the better the level of the student's mathematical critical thinking ability. This research is quantitative research (quasi-experimental), while the research subjects are students at one of Pekanbaru's state junior high schools class VII for the academic year 2022/2023, as many as 30 students who are randomly selected by the class. This research was conducted on the material of flat shapes, especially triangles and quadrilaterals. The data collection method used was a mathematical critical thinking ability test. The test result data was processed by statistical tests, including a normality test, homogeneity test and two-way ANOVA test. The results showed that the improvement of mathematical critical thinking skills of students who received learning using augmented reality media with Unity 3D was better than the improvement of mathematical critical thinking skills of students who received conventional learning based on students' initial mathematical abilities.

Penulis Koresponden:
Lilis Marina Angraini
Universitas Islam Riau
Mathematics Education, FKIP, Universitas Islam Riau, Riau, Indonesia
lilismarina@edu.uir.ac.id

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INTRODUCTION

One of the goals of learning at school is the formation of students' critical thinking skills, one of the subjects considered to be able to form critical thinking skills in mathematics, and this is in line with the Regulation of the Minister of National Education which states that mathematics subjects need to be given to all students at every level of education to equip students with higher-order thinking skills, one of which is the ability to think critically.

Mathematical critical thinking is intelligence that students must possess in solving mathematical problems (Yanti & Prahmana, 2017). Mathematical critical thinking skills are very important to develop because mathematical critical thinking skills play an

important role in solving mathematical problems. Students with good critical thinking skills can solve mathematical problems better than those with low or moderate critical thinking skills (Warniasih et al., 2019).

According to (Muslimahayati, 2020) a good critical thinker can be seen from his ability to find facts, data, and concepts and produce the right solution to a problem. A good critical thinker can apply different strategies, provide reasons for applying standards in solving mathematical problems and be able to provide clarification on matters relating to a given problem.

Mathematical critical thinking skills, of course, provide many benefits for students, including students can have a better understanding and development of concepts, and students can develop thinking skills to solve more complex problems more easily. Critical thinking ability is related to a student's ability to solve problems to draw logical and valid conclusions (Maulidah et al., 2020; Ucisaputri et al., 2020).

Critical thinking skills and mathematical concepts are two interrelated things because critical thinking skills can develop through learning mathematics which is rich in concepts, while mathematical concepts can be understood through critical thinking skills (Karim & Normaya, 2015; Nashrullah et al., 2021). Critical thinking ability is an ability that students have when they can analyze facts, generalize and organize ideas to solve problems, defend these ideas, be able to compare them, and then test their arguments and draw conclusions (Anita & Firmansyah, 2022; Nurdiansyah et al., 2021).

One of the factors that determine the success of forming students' critical thinking skills is expertise in choosing and using appropriate learning media. With the applied learning media, students are expected to be able to form, develop and even improve critical thinking skills. One of the learning media that is thought to be able to facilitate the formation of critical thinking skills is learning media that is integrated with technology.

Media has a meaning as a tool to make it easier to convey information (messages) between the sender and the recipient of the message. According to (Nugroho & Pramono, 2017) media is a tool of all forms which has the aim of facilitating the process of delivering information. (Deli, 2020; Putra, 2013) argues that the use of learning media that is applied to the learning process can increase students' interest in following the material presented by the teacher.

(Mauludin et al., 2017) revealed that learning media that can motivate students in the implementation of learning is by utilizing learning media that are suitable for students' needs for learning materials and can encourage students to learn so that the learning outcomes obtained can increase. The main function of learning media is as a teaching aid that also influences the climate, conditions, and learning environment.

The existence of learning media in the teaching and learning process is very beneficial for teachers and students. The benefit of its use is that the media is able to clarify the presentation of messages or information to be conveyed to students (Estheriani & Muhid, 2020). By using learning media, teachers can make it easier to direct student's attention during the teaching and learning process and can increase students' interest in learning themselves.

The use of technology is very helpful in teaching and learning activities. Technological progress can be felt in various sectors of human life today. Educators need to develop learning media in an interesting way without changing the content of a material. Augmented reality is currently an alternative in the development of learning media. Through learning with Augmented reality media, it can hone and give birth to creativity in students (Nurrisma et al., 2021).

Effective learning media will also be able to encourage students to learn independently so as to form student-centered learning. For this reason, in realizing effective learning media, it is necessary to use technology. One of these technologies is virtual technology which is one of the products of the industrial revolution 4.0. This was chosen because virtual technology is able to accurately represent real objects in providing information. One example of virtual technology is Augmented Reality (Chen & Wang, 2015).

Literally, Augmented Reality technology can be defined as a platform that can combine virtual objects into the real world as these two objects seem to blend with each other. Augmented Reality is a technique of combining concrete things with virtual things in two-dimensional and three-dimensional forms that are projected on a concrete environment at the same time (Mantasia & Jaya, 2016).

According to (Ginting et al., 2017) Augmented reality is a technology that combines two-dimensional and or three-dimensional pseudo objects into a real three-dimensional environment and then projects these pseudo objects in a real environment. According to (Mantasia & Jaya, 2016) augmented reality is a direct or indirect view of a physical object by entering information that can be displayed virtually.

In augmented reality, there are three characteristics that become a reference for the system, including a combination of the real and virtual worlds, interactions that run in real-time, and the last characteristic is the shape of the object in the form of a 3-dimensional or 3D model (Mustaqim, 2016). According to (Wardani, 2015), there are three characteristics that state that technology applies the concept of augmented reality, namely being able to: combine the real world and the virtual world, provide interactive and real-time information, and display in three dimensions.

Based on the above definition, simply AR can be defined as a real environment that is added by virtual objects with the integration of computer technology. This technology can provide an interesting interaction for the user because with this technology, and the user can feel virtual objects as if they really exist in a real environment. In its application, AR technology has several components that must be present to support the performance of the digital image processing process.

AR is a new form of human-machine interaction that brings new experiences for users. The virtue of AR is that AR can cause computer animation picture effects in the real world. The AR application uses a webcam that will detect markers that have been created and display a combination of real images and animations. Webcam is used as the 'eye' of AR technology to detect markers, process them and produce virtual interactions that appear on the real screen display (Kiryakova et al., 2018).

In the learning process, innovations are needed, especially in technology and media development. Technology is a means that allows the creation of the necessary learning

environment in which the learning process can be realized in the most effective way (Sirakaya & Cakmak, 2018). One of the uses of technology in education is used Augmented Reality (AR) technology. By looking at the cognitive stage development experienced by students, AR technology may be preferred in learning, especially in teaching abstract concepts (Arifitama, 2017).

The application of AR technology innovation in learning will form an effective learning atmosphere and provide an overview of the real-world environment in a computer-based learning system. AR is applied in the world of education because of its virtue by combining real-world situations and virtual objects that can be used to overcome problems in understanding the lessons delivered (Kiryakova et al., 2018).

According to (Sirakaya & Cakmak, 2018) the use of augmented reality is very useful as an interactive learning medium and can be used directly by students. In addition, learning media using augmented reality can build students' interest in learning because of the interactive nature of augmented reality so that it can develop students' imaginations with the real world directly.

Learning media using augmented reality technology can easily improve students' understanding because 3D objects, text, images, videos, and audio can be shown to students in real terms (Sidik & Vivivanti, 2021). Students can be involved interactively, which causes augmented reality to become a learning medium that can provide feedback to students so that students get comfortable using the media.

Learning media with the use of augmented reality is an intermediary tool between educators and students in learning that is able to connect, provide information and distribute messages so as to create an effective and efficient learning process. Learning media resulted in communication between educators and students in the learning process (Setyawan, 2019). According to (Idhami et al., 2020) the implementation of AR learning media is able to help students reconstruct knowledge and skills and connect knowledge with those faced in the real world.

(Hendriyani et al., 2019) who stated that augmented reality technology has the ability to create any 3D model that might be difficult to visualize in the classroom, on the computer or in the minds of students. According to (Sa'diyyah et al., 2021)s states that the use of augmented reality technology in learning has several advantages, namely, it has excellent potential and great benefits in the learning process.

Research related to the importance of critical thinking skills has been carried out by (Muslimahayati, 2020; Ucisaputri et al., 2020; Yanti & Prahmana, 2017). The researcher focuses on identifying the relationship between problem-based learning models and critical thinking skills, developing critical thinking questions based on local wisdom, and identifying the linkages between scientific learning models and critical thinking skills. Meanwhile, research on the application of AR media in learning has been carried out by . The researcher focuses on identifying the application of AR in the introduction of building objects and identifying the application of AR as a learning medium.

A person's ability to learn includes how best to learn to do, what is already known, and what is not yet known as well as an evaluation of what is planned. The initial ability of a student in the teaching and learning process is very necessary, especially to equip

students to learn higher material (Gais & Afriansyah, 2018; Purnamasari & Setiawan, 2019; Zulkarnain, 2019). Students who have a higher initial ability will easily understand and understand the subject matter presented by the teacher and allowing them to get better learning achievement. Therefore, this study aims to see the improvement of students' mathematical critical thinking skills who receive learning using augmented reality media with Unity 3D based on students' initial mathematical abilities.

METHODS

This research method is experimental, and this method is carried out to find the effect of certain treatments. The design of this study was a quasi-experimental nonequivalent control group because the students who were respondents in this study were not randomly selected, but the researchers randomized the existing classes.

This research was carried out in one of the Pekanbaru State Junior High Schools for class VII students in the 2021/2022 academic year on the material of flat shapes (triangles and quadrilaterals). The subjects of this study were 30 students consisting of 2 classes, namely the experimental class and the control class. The experimental class was given learning using AR-based learning media with 3D unity, while the control class was given teaching materials in the form of Student Worksheets. Each teaching material aims to form effective learning so that students have better critical thinking skills.

This study looks at the effect of testing the results of initial mathematical ability in distinguishing students' critical thinking abilities. Good mathematical ability tends to show a good level of thinking ability and vice versa. Poor mathematical ability tends to show a poor level of thinking ability as well. Thus, this study will also look at students' initial mathematical ability as one of the determining factors in distinguishing the improvement of students' critical thinking skills through the application of AR media with 3D unity.

The data of this study were collected through tests. The test given is in the form of questions about mathematical critical thinking skills. Tests are given at the beginning and at the end of the lesson. The test was first validated by experts. Then the data was analyzed using the 2-way ANOVA test. Prior to the 2-way ANOVA test, the data were tested for prerequisites, in this case, to ensure that the data met the normality and homogeneity assumption tests. The normality test used the Kolmogorov-Smirnov test, and the homogeneity test used the Levene test. If the data distribution does not meet the normality assumption test, then the data will be analyzed using a non-parametric test, namely the Adjusted Rank Transformation Test.

RESULTS AND DISCUSSION

This study aims to examine, describe, and compare the differences in the improvement of mathematical critical thinking skills between students who receive learning using augmented reality media with Unity 3D and conventional learning based on students' initial mathematical abilities. Initial mathematical ability of students consists of three categories, namely: high category, medium category, and low category. The following is the distribution of the research sample.

Table 1. The Data Distribution of Research Samples

IMA	Control	Experiment (AR)	Amount
High	5	5	10
Medium	5	5	10
Low	5	5	10
Total	15	15	30

Description: AR = Augmented Reality.
Control = Conventional Learning.

Statistical analysis of test results using SPSS 26.0 software which includes: descriptive statistics, Kolmogorov-Smirnov normality test, Levene homogeneity test, t-test, and two-way ANOVA test. Before carrying out statistical tests, assumptions were first tested, namely the normality test of the data and the homogeneity of variance test. In this chapter, a summary of the results of data analysis from all these tests will be presented, and with their discussion.

Data on initial mathematical abilities were collected and analyzed to determine students' initial mathematical abilities before this research was carried out. The initial mathematical ability is obtained from the mathematical value in the previous subject. The scores are then grouped based on the high, medium, and low initial ability categories. To obtain an overview of the student's initial mathematical abilities, the data were analyzed descriptively in order to know the mean, standard deviation, minimum value, and maximum value. The summary of the results of descriptive analysis of students' initial mathematical ability data based on previous learning outcomes is presented in the following table:

Table 2. The Data Description of Student Initial Mathematical Ability

Descriptive Statistics	Control	Experiment (AR)
N	15	15
$\bar{X}$	81,52	80,45
Sd	6,64	6,12
Max	98	100
Min	64	65

In the table above, it can be seen that the description of the initial mathematical ability of the control class is better than the experimental class. But the difference is not

too much. The reason for the researchers to still choose the group of students who have an average of 80.45 as the experimental class is because the researchers want to make the average experimental class (the group that gets augmented reality media learning with Unity 3D) better than the average. The average control class (the class that received conventional learning) as a whole.

Furthermore, the equivalence test of the initial mathematical abilities of the two learning groups will be carried out using the t-test, but before carrying out the t-test, the data normality test and the homogeneity of variance test will be carried out first. The normality test of the data used is the Kolmogorov-Smirnov test. The results of the normality test of the student's initial mathematical ability data for the two learning groups are presented in the following table:

Table 3. Normality Test of Student Initial Mathematical Ability

Kolmogorov-Smirnov	Control	Experiment (AR)
N	15	15
Sig.	0,38	0,50

In the table above, it can be seen that the probability value (sig.) of the data on conventional learning and augmented reality media with Unity 3D is more than 0.05. This means that H0 is accepted, so it can be concluded that the sample data for the two groups came from a normally distributed population. Furthermore, the homogeneity of the variance of the initial mathematical ability of the two groups will be tested using Levene's test. The results of the homogeneity test of the data for the initial mathematical ability of students in the two learning groups are presented in the following table:

Table 4. The Homogeneity Test of Student Initial Mathematical Ability

Levene-test	Data	Criteria
N	30	H_0 Accepted
Sig.	0,27	

In the table above, it can be seen that the probability value (sig.) of the data is greater than 0.05. This means that H_0 is accepted, so it can be concluded that the data variance of the two groups is homogeneous. Furthermore, the equality of the initial mathematical ability data will be tested using the t-test. The results of the data equivalence test of students' initial mathematical abilities based on learning are presented in the following table.

Table 5. The Equivalence Test of Student Initial Mathematical Ability

t-test	Data	Criteria
N	30	H_0 Accepted
Sig. (2-tailed)	0,33	

In the table above, it can be seen that the probability value (sig.) is greater than 0.05, so H_0 is accepted. Thus, there is no difference in the average initial mathematical ability between students who receive learning using augmented reality media with Unity 3D and students who receive conventional learning. This further strengthens the statement in the previous table 2 that, overall, there is no significant difference in the description of the initial mathematical ability of the control class and the experimental class.

Then to see the difference in increasing mathematical critical thinking skills of students who receive learning using augmented reality media with Unity 3D based on students' initial mathematical abilities, a two-way ANOVA test will be carried out. In order to obtain an overview of the quality of mathematical critical thinking skills of the two groups of students, the data were analyzed descriptively so that the mean, standard deviation, minimum value, and maximum value could be known. The summary of the results of the descriptive analysis of students' mathematical critical thinking ability data in the two lessons is presented in the following table.

Table 6. The Description of Data Gain Students' Critical Thinking Mathematical Ability

Learning	Ability	Mean of Gain	Sd
AR	High	0.81	0.13
	Medium	0.72	0.10
	Low	0.69	0.09
Control	High	0.64	0.11
	Medium	0.53	0.06
	Low	0.50	0.06

In the table above, it can be seen that the data description of students' mathematical critical thinking abilities who received conventional learning was not better than students who received learning using augmented reality media with Unity 3D. This means that the overall average mathematical critical thinking ability of students who received learning using augmented reality media with Unity 3D is better than the overall average mathematical critical thinking ability of students who received conventional learning based on initial mathematical ability.

Before testing the average difference, the data normality and homogeneity of variance will be tested first from the data on the mathematical critical thinking ability of students who receive learning using augmented reality media with Unity 3D (experimental class) and conventional learning (control class). The normality test of the data used is the Kolmogorov-Smirnov test. The results of the normality test of the student's mathematical critical thinking ability data for the two learning groups are presented in the following table:

Table 7. The Normality Test of Data Gain Students' Critical Thinking Mathematical Ability

Kolmogorov-Smirnov	Control	Experiment (AR)
N	15	15
Sig.	0,08	0,20

From the table above, it can be seen that the significance value of the mathematical critical thinking ability of the two learning groups is greater than 0.05. This means that the null hypothesis is accepted. That is, the data on students' mathematical critical thinking skills for both the control class and the experimental class is normally distributed.

Furthermore, the homogeneity of the variance of critical thinking skills of the two sample groups will be tested using Levene's test. The results of the homogeneity test of the data variance of students' mathematical critical thinking abilities in the two learning groups are presented in the following table.

Table 8. The Homogeneity Test of Data Gain Students' Critical Thinking Mathematical Ability

Levene-test	Data	Criteria
N	30	H_0 Accepted
Sig.	2,09	

From the table above, it can be seen that the significant value of the homogeneity of the data variance of mathematical critical thinking abilities of students who received learning using augmented reality media with Unity 3D (experimental class) and conventional learning (control class) was greater than 0.05. This means that the null hypothesis is accepted. Because the mathematical critical thinking ability data of the two learning groups meet the assumptions of data normality and homogeneity of variance, then next to see if there is a significant difference between the average mathematical critical thinking ability of students who receive learning using augmented reality media with Unity 3D (experimental class) and students who receive conventional learning (control class), and whether there is an effect of the interaction between the learning used and the initial mathematical ability on students' mathematical critical thinking skills will be tested using two-way ANOVA. The calculation results are presented in the following table.

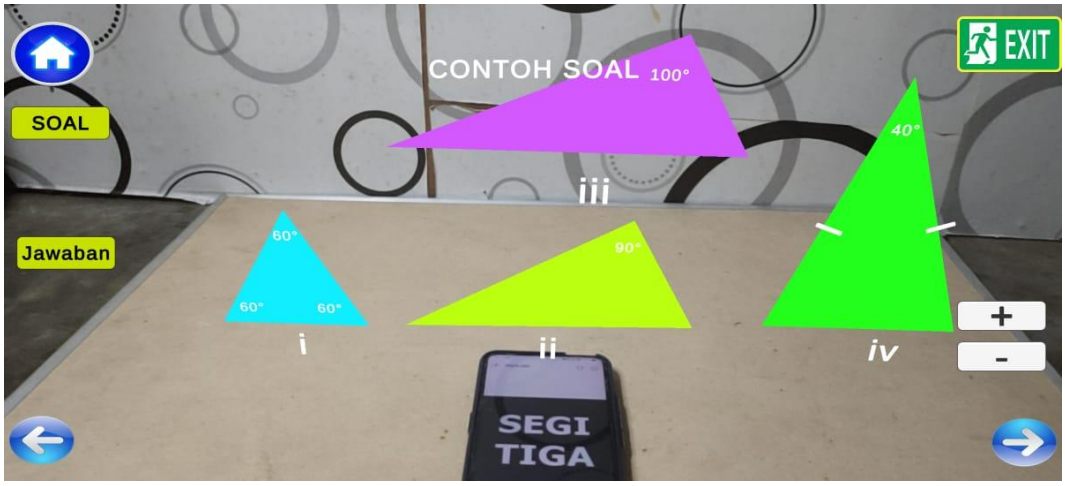
Table 9. The Two-way ANOVA test of Data Gain Students' Critical Thinking Mathematical Ability

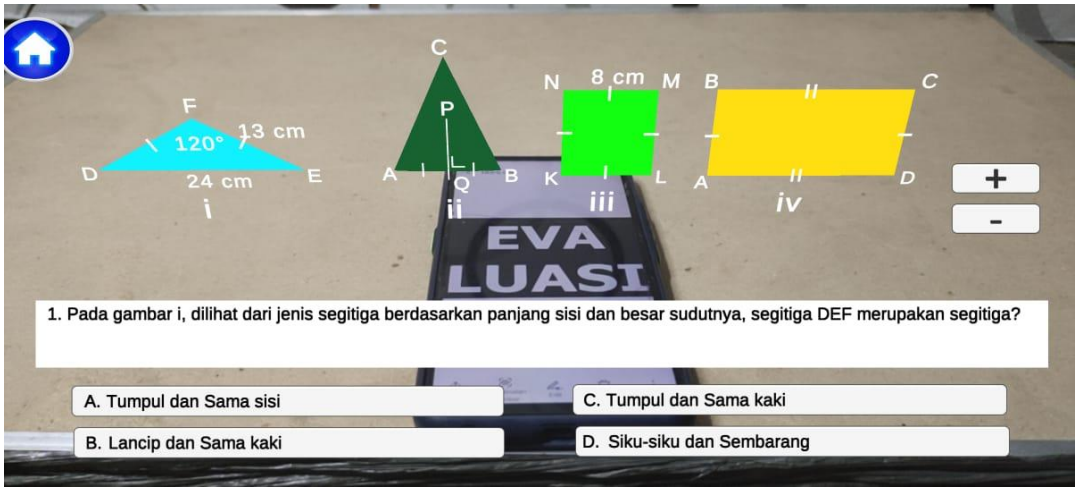
	Total	Dk	Average square	F	Sig.	H_0
Learning	1642,80	1	1642,80	54,69	0,00	Rejected
IMA	7942,06	2	3971,03	132,22	0,00	Rejected

	Total	Dk	Average square	F	Sig.	H_0
Interaction	300,20	2	150,10	4,99	0,01	Rejected
Error	720,80	24	30,03			
Total	125678,00	30				

From the table above, it can be seen that the initial mathematical ability factor used by each learning group has a significant influence on students' mathematical critical thinking skills. This can be seen from the significance value obtained at 0.00, which is smaller than 0.05. This means that there is a significant difference between the average mathematical critical thinking ability of students who receive learning using augmented reality media with Unity 3D (experimental class) and students who receive conventional learning (control class) based on students' initial mathematical abilities.

(Hendriyani et al., 2019) revealed that augmented reality technology has the ability to create any 3D model that may be difficult to visualize in the classroom, on a computer, or in the minds of students. According to (Sa'diyyah et al., 2021) stated that the use of Augmented reality technology in learning has several advantages, namely, it has excellent potential and great benefits in the learning process. The following is the display of Augmented reality media on triangle and quadrilateral material:





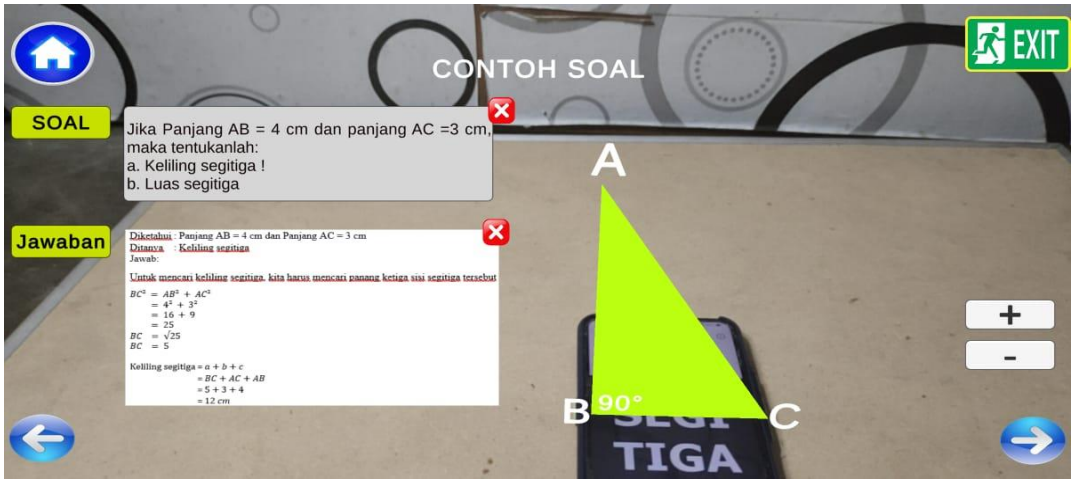


Figure 1. Augmented Reality view on triangles and rectangles

AR is a form of human and media interaction that brings new experiences to its users. The virtue of AR is that AR can cause animated picture effects in the real world. Augmented Reality has advantages as an educational medium. It has been proven in this study that this technology has a considerable influence on increasing students' mathematical critical thinking skills who receive learning using augmented reality media with Unity 3D based on students' initial mathematical abilities. The following is the process of implementing and answering student test results in the experimental class:

Figure 2. Experimental class learning process

Indicators of critical thinking skills used in this study are: (1) the ability to identify relevance; in this ability, students collect information that is known and asked and identify keywords contained in mathematical problems. This means that the ability to identify the relevance of students is good; (2) the ability to formulate problems into students' mathematical models is good. In this ability, students identify the relationship

between parts of the problem by linking related information, and students also link problems with other materials that will be used in solving. Students use the general formula for the multilevel number U_n pattern to answer questions, and students understand when substituting numbers into the formula they use. Students are creative in thinking to solve mathematical problems contained in the problem. (3) the ability to deduce using principles. In this ability, students have met the critical thinking indicators. However, students are negligent in drawing conclusions because students forget to write down the information starting from how many. But students can answer it when interviewed. Meanwhile, from the answers to the control class test, it was concluded that students had not been able to meet the critical thinking ability indicators used in this study because: (1) students could not identify the keywords contained in mathematical problems; (2) the ability to identify the relevance of students is not good on the questions; (3) the ability to formulate problems into mathematical models of students is not good, because students are wrong when using the Pythagorean formula and the formula for the area of a triangle; (4) Students make mistakes in compiling the steps they use in solving problems and drawing inappropriate conclusions.

Learning using augmented reality media with Unity 3D has a good influence on students' mathematical critical thinking skills, especially on flat-shaped material, this is evident from the overall average acquisition of mathematical critical thinking skills obtained by the experimental class, which is 69.33, this shows that the average critical thinking ability in the experimental class is higher than the average critical thinking ability in the control class based on the student's initial mathematical abilities, while the biggest obstacles are: (1) the transition process to feel comfortable with the AR media format and platform which is still considered new to the school; (2) some students are still rigid in using the application at the beginning of learning; (3) there are several types of cellphones that cannot install AR applications (mobile phones type Vivo Y93 and Realme 5i); (4) some students experienced application errors such as the number of degrees that disappeared and appeared. But overall, students find this application interesting and very easy to use.

AR media can be used to improve critical thinking abilities and can help students meet their learning objectives. The usage of augmented reality (AR) media in the classroom is advantageous for imparting information and skills as well as pique students' interest and attention, leading to more focused and regulated learning (Mustaqim, 2016; Sidik & Vivivanti, 2021). Three concepts govern how augmented reality (AR) works: it merges the real and virtual worlds; it is interactive and real-time; and it incorporates three-dimensional items, namely virtual objects that are merged into the real environment. The learning process is considerably aided by the concepts of augmented reality (AR), which helps pupils strengthen their critical thinking abilities, especially in flat shapes (triangles and quadrilaterals).

The researchers observed that male students were more enthusiastic about using augmented reality (AR) media during the learning process. This enthusiasm was

demonstrated by the students' greater activity in asking questions, their greater eagerness to explain the outcomes of their answers, and their greater eagerness to move AR applications. According to the study, it is important to consider gender when implementing learning using AR media, especially to enhance students' critical thinking abilities. This is also consistent with the hypothesis that student learning results are influenced by gender-specific characteristics.

CONCLUSIONS

Based on the results of data processing, analysis, and discussion that have been presented in the previous chapter, the following conclusions are obtained: The improvement of mathematical critical thinking skills of students who receive learning using augmented reality media with Unity 3D is better than increasing mathematical critical thinking skills of students who receive conventional learning based on students' initial mathematical abilities. Furthermore, it is necessary to look at the magnitude of the increase in each student in terms of mathematical critical thinking skills or other higher-order thinking skills in the application of augmented reality learning media with 3D unity.

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