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The Effect of Problem Based Learning Model Assisted by Augmented Reality Media on Critical Thinking Students

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Abstract - Problems in the learning process are that many students lack focus and lack motivation to learn when the teacher delivers the material. The cause is one of the learning models that is less interactive, where teachers often use a one-way learning approach. In addition, teachers have not mastered or utilized more interactive learning media outside of using PowerPoint. This condition not only reduces the effectiveness of learning, but also has a negative impact on students' critical thinking. The purpose of this study was to analyze the effect of implementing the Problem Based Learning model assisted by Augmented Reality media on students' critical thinking in Computer Engineering and Networking subjects at state vocational high school 1 Bukittinggi. This study is included in the type of qualitative research with an experimental method, using the Quasi Experimental Design model in the form of Nonequivalent Control Group Design. The subjects of this study were all class XI TJKT students in the 2024/2025 academic year. Based on the results of the data analysis, it shows a significant effect of the application of the Problem Based Learning model assisted by Augmented Reality media on the critical thinking of Computer Engineering and Networking students with a contribution of 73.65%.

Keywords — Problem Based Learning, Augmented Reality, and Critical Thinking.

I. INTRODUCTION

Merdeka curriculum is an educational approach designed to provide freedom and flexibility to students in the learning process. Through this approach, students are given the opportunity to learn independently, exploring various topics that suit their interests, talents, and needs, so that their potential can develop optimally. This approach also aims to train students to be more skilled in critical thinking, namely the ability to analyze, evaluate, and solve various problems logically and creatively. With the Independent Curriculum, students are not only passive participants in learning, but also actively contribute to the process, which ultimately equips them with the skills to face real-world challenges effectively [1] . Critical thinking is one of the important skills that individuals must have to face various challenges in the modern era [2]. This ability involves a process of in-depth analysis of an idea or information with the aim of obtaining relevant, accurate, and accountable knowledge. In critical thinking, individuals do not only receive information, but also test its validity and reliability through various perspectives.

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This process includes the ability to evaluate arguments, identify hidden assumptions, and consider the implications of decisions taken. Thus, critical thinking is not only about understanding an idea, but also about processing and managing information logically and systematically to produce appropriate and useful solutions in various situations [3] . Critical thinking skills are very important skills for students to face a world that is constantly changing and full of complex challenges. By thinking critically, students can analyze situations, evaluate various options, and make the right decisions based on logical thinking and accurate information. Therefore, the role of teachers is very crucial in creating a dynamic and inspiring learning environment. Teachers need to apply interactive learning methods, such as group discussions, case studies, and collaborative projects, which allow students to be actively involved in the learning process. Through this approach, students not only understand the subject matter theoretically, but are also trained to relate it to real contexts, solve problems, and express their ideas critically and creatively. However, in reality, the application of critical thinking skills in the world of education today is still relatively low. This shows the need for a paradigm shift in learning, where the focus is not only on the transfer of knowledge, but also on the development of high-level thinking skills that are important provisions for students' futures. [3] .

Several factors contribute to this low ability, including students' tendency to memorize material rather than understand it. Research by Sianturi upports this, showing that there is a lack of student response, such as a lack of questions and opinions submitted by students [2]. This indicates that students tend to focus more on the teacher's explanation without analyzing, criticizing, or evaluating the information presented [4] . Critical thinking skills can be improved through the application of learning models specifically designed to encourage students to actively think and solve problems. One learning model that has

proven effective in developing these skills is Problem Based Learning. This model focuses on providing real problems as a starting point for learning, which encourages students to explore information, analyze data, and find creative solutions independently or collaboratively. This statement is supported by the results of research conducted Muslim which shows that the application of Problem Based Learning significantly improves students' critical thinking skills compared to conventional learning methods[5]. The study also revealed that students involved in Problem Based Learning became more skilled at evaluating information, constructing logical arguments, and making decisions based on mature analysis, which shows that the application of the Problem Based Learning model in learning can improve students' mastery of concepts and increase their Critical Thinking.

Problem Based Learning an innovative learning approach that makes problems the core of the learning process. In this model, students are faced with real or contextual problems that are relevant to the learning topic, which serve as a stimulus for exploring knowledge. This process encourages students to analyze problems in depth, develop inquiry skills, and design creative and logical solutions. Through Problem Based Learning, students not only gain a conceptual understanding of the material, but are also trained to think critically, integrate various sources of information, and work collaboratively in groups. This approach also helps students hone effective problem-solving skills, which are important provisions for facing real-world challenges. By placing students as active subjects in learning, Problem Based Learning motivates them to be more involved, take responsibility for the learning process, and significantly improve their high-level thinking skills. [6] . Problem Based Learning can be combined with learning media to make the learning process more fun and interesting. Learning media refers to anything that can be used to convey learning messages from educators to students, with the aim of creating a learning experience that can attract attention, arouse interest, stimulate thinking, and influence students' feelings. [7] .

Based on the results of observations conducted during the implementation of Educational Field Practice at SMK Negeri 1 Bukittinggi in the Computer Network Engineering and Telecommunications Department in June - December 2023, it was found that during face-to-face learning, especially in the Computer and Network Engineering subject, many students were still less focused when the teacher delivered the material. This is due to the limited use of interactive media by teachers, who still rely on a one-way learning model. As a result, group activities become passive, less critical, and not creative, which has an impact on the low level of Student Critical Thinking . The low level of Student Critical Thinking will affect their learning outcomes, such as the grades obtained on network material, types of cables, and fiber optic work tools in class XI TJKT. This can be seen from the learning outcomes of students, where most of them do not achieve the Learning Objective Achievement Criteria (KKTP) with a score of 80.

One of the learning media permitted at SMK Negeri 1 Bukittinggi during the learning process is the smartphone interactive learning media that can be used for TKJ subjects on networks, cable types, and fiber optic work tools, namely interactive learning media based on Augmented Reality technology. Augmented Reality (AR) is a technology that allows combining two or three-dimensional virtual objects into a real environment, then displaying or projecting them directly in real time[8]. One of the platforms that supports the widespread use of AR is Android, a mobile operating system developed by Google. Referring to the explanation and problems that have been explained, the author is interested in conducting a study entitled The Effect of Problem Based Learning Model with the help of Augmented Reality Media on Students' Critical Thinking in Computer Engineering and Network Subjects.

II. METHOD

This research is included in the type of qualitative research with experimental methods. The experimental method aims to identify the influence that occurs between two or more variables. The experimental research method is an approach used to investigate the effect of a treatment on other variables in controlled and structured conditions [9]. The type of design used in this study is the Quasi Experimental Design with the Nonequivalent Control Group Design model . In this design, there are two groups that are given a pretest to measure the initial conditions and to find out whether there is a difference between the experimental group and the control group. The pretest results are considered good if the experimental group's values do not show a significant difference with the control group[10]. This research was conducted at State Vocational School 1 Bukittinggi.

This study involved two groups, namely the experimental group and the control group. The experimental group will be treated with the application of the Problem Based Learning model using Augmented Reality (AR) Media, while the control group will follow the conventional learning model.

The following is a description of the Nonequivalent Control Group Design research design [9] :

O_1	x	O_2
O_3		O_4

Figure1. Nonequivalent Control Group Design

Information :
O_1 = pretest experimental group
O_2 = posttest of experimental group
O_3 = pretest control group
O_4 = control group posttest
X = learning with PBL model treatment assisted by AR media

In this study, the instruments used were pretest and posttest questions consisting of 20 questions. These questions have been tested to measure validity, reliability, discrimination, and level of difficulty. The posttest learning outcome data of students in the experimental group were analyzed to measure the increase in students' Critical Thinking before and after learning, in order to see the extent of the influence of the use of Augmented Reality learning media . Student learning outcome data were analyzed using the N-Gain test to determine the increase in students' understanding after being given treatment, namely the application of the Problem Based Learning model

with the help of Augmented Reality media [11]. In addition, the hypothesis test (t-test) was used to evaluate the difference in average scores between sample groups significantly. Before the hypothesis test was carried out, the normality and homogeneity tests were first carried out to consider the feasibility of implementing the hypothesis test[12].

The following is the Cohen's d effect size formula used in this study:

$$d = \frac{M_2 - M_1}{S_{pooled}}$$

information :

d	= cohen's d effect size
M_1	= average pretest score
M_2	= average posttest score
S_{pooled}	= pooled standard deviation

The combined standard deviation can be calculated using the following equation:

$$S_{pooled} = \sqrt{\frac{SD_1{}^2 + SD_2{}^2}{2}}$$

Information :
SD1 = variance of pretest scores
SD2 = variance of posttest scores

III. RESULTS AND DISCUSSION

This study involved students of group XI TJKT SMK Negeri 1 Bukittinggi, consisting of 32 students in the experimental group and 32 students in the control group. The purpose of this study was to analyze the effect of the application of the Problem Based Learning model supported by Augmented Reality media on students' Critical Thinking in Computer and Network Engineering subjects at SMK Negeri 1 Bukittinggi.

A. Results

Problem Based Learning model supported by Augmented Reality media in this study was analyzed based on the average increase in student scores, which were tested using the N-Gain test and hypothesis test.

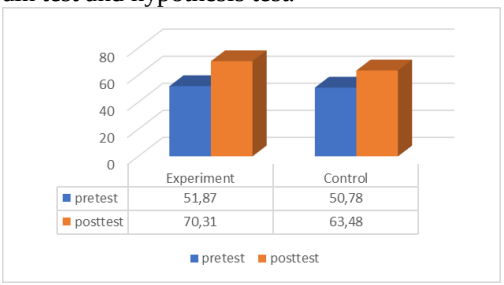

Figure 2Diagram of the Average Values of the Experimental Group and the Control Group

Based on Figure 2, the average pretest score in the experimental group was 51.87, while in the control group it was 50.78. The purpose of this pretest was to measure students' initial understanding of the introduction to fiber optic equipment material. The average posttest score in the experimental group was 70.31, while in the control group it reached 63.48. This posttest was given to assess the extent of students' understanding of the material after the learning was completed.

Before conducting the N-Gain test and hypothesis test, the first step is to conduct a normality test to check whether the data obtained is normally distributed. Then, conduct a homogeneity test to ensure whether the data from various groups have the same variance.

The results of this study include testing the hypothesis of the effect of implementing the Problem Based Learning model with the help of Augmented Reality media on students' Critical Thinking . In addition, N-Gain score testing was also carried out to evaluate the increase in student understanding after the Problem Based Learning model was implemented with the help of Augmented Reality media. [12] .

TABLE I
HYPOTHESIS TEST

	t-test for Equality of Means				
	T	Df	Sig (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.94	62	.005	6.87500	2.33719
Equal variances not assumed	2.94	61.70	.005	6.87500	2.33719

Hypothesis testing was conducted using the independent sample test method because the student learning outcome data had been normally distributed and homogeneous. Based on Table 1, the sig value (2-tailed) is 0.005, which is smaller than 0.05. These results show a significant influence between the dependent variable and the independent variable, indicating that the difference in treatment given to each variable has a significant influence. So it can be concluded that Ha is accepted and H0 is rejected. For the calculated t value> t table (2.942> 1.670) where the t table is obtained at α = 5% with (df) = 62, the t table is 1.670. Because the calculated t> t table, Ha is accepted [13] .

Hipotesis null adalah pernyataan yang menunjukkan tidak adanya perbedaan, pengaruh, atau efek dalam suatu penelitian. Oleh karena itu, hipotesis ini juga disebut sebagai hipotesis nihil, yang menegaskan ketiadaan perubahan atau hubungan yang signifikan. Hipotesis alternatif (Ha) merupakan kebalikan dari hipotesis null, yaitu hipotesis yang menyatakan adanya perbedaan, pengaruh, efek, atau hubungan tertentu. Hipotesis ini menunjukkan bahwa terdapat sesuatu yang signifikan dengan berbagai kemungkinan alternatif [15].

H_0 : There was no significant positive influence between the application of the Problem Based Learning learning model with the help of Augmented Reality media on the Critical Thinking of group XI students in the Computer and Network Engineering subject at SMK Negeri 1 Bukittinggi.

H_a : A significant positive influence was found between the application of the Problem Based learning model

Learning with the help of Augmented Reality media on Critical Thinking of group XI students in Computer and Network Engineering subjects at SMK Negeri 1 Bukittinggi.

TABLE II
N-GAIN TEST

	N	Minimum	Maximum	Mean	Std Difference
N-Gain Experiment	32	.10	.73	.3828	.02973
N-Gain Control	32	-.25	.64	.2408	.03496

Based on the results of the analysis of table 2, the N-Gain test of the experimental group was 0.38, it can be concluded that the category of the N-Gain Score division is included in the moderate category. Meanwhile, the average N-Gain score for the control group was 0.24, which is included in the low category. Therefore, it is concluded that the application of the Problem Based Learning model with the help of Augmented Reality media is effective in improving students' Critical Thinking .

To measure the extent to which the Problem Based Learning model influences with the help of Augmented Reality media on the Critical Thinking of group XI students in the Computer and Network Engineering subject at SMK Negeri 1 Bukittinggi, an effect size test can be carried out . [14] .

Cohen's d = (70.31 – 63.43.875)/9.340656 = 0.7365 * 100% = 73.65%

So from the calculation using this formula, the Cohen's d value obtained is 73.65%. If we look at the criteria table, it can be concluded that the Cohen's d effect size value is included in the moderate criteria.

B. Discussion

The results of the normality calculation show that the control group data has a pretest significance value of 0.200 and a posttest of 0.102, which indicates that the data is normally distributed. Meanwhile, the experimental group data has a pretest significance value of 0.068 and a posttest of 0.080, so the data is also declared normally distributed. Thus, both data from the control group and the experimental group are in a normal distribution. Furthermore, the results of the homogeneity test in the table show a significance value of 0.986, where this value is greater than 0.05, so the data has a uniform or homogeneous variance.

According to the data analysis conducted using SPSS version 25.0, the sig value (2-tailed) obtained was 0.005, which is smaller than 0.05. This result indicates that a significant influence was found between the dependent variable and the independent variable, and shows that different treatments on each variable have a significant impact. Thus, it can be concluded that Ha is accepted and H0 is rejected. For the value of t count> t table (2.942> 1.695) where t table is obtained at $\alpha = 5\%$ with (df) = 62, it is obtained for t table of 1.695. Because t count> t table, then Ha is accepted. This indicates that the application of the Problem Based Learning learning model has a positive and significant influence with the help of Augmented Reality media on Critical Thinking of class XI students in the Computer and Network Engineering subject at SMK Negeri 1 Bukittinggi.

The results of the N-Gain test showed that the average N-Gain score for the experimental group was 0.38, which is included in the medium category. Meanwhile, the average N-Gain score for the control group was 0.24, which is included in the low category. Based on these results, it can be concluded that the application of the Problem Based Learning model with the help of Augmented Reality media is effective in improving students' Critical Thinking .

To measure the level of influence of the Problem Based Learning model with the help of Augmented Reality media on students' Critical Thinking , an effect size test was conducted using Cohen's d value as an indicator. The calculation results showed a Cohen's d value of 73.65%. This indicates that the application of the Problem Based Learning model with the help of Augmented Reality media is effective in improving students' Critical Thinking . So it can be concluded that the Problem Based Learning model assisted by Augmented Reality media has an influence of 73.65% with a moderate category on students' Critical Thinking in the Computer and Network Engineering subject at SMK Negeri 1 Bukittinggi.

This result is in line with the research conducted by Andriani and A. Ramadani . In this study, the Augmented Reality variable gave an influence of 75.2% on students' Critical Thinking , which shows that the application of Augmented Reality media can improve students' Critical Thinking [17]. This finding is also in line with the research conducted by Fannisa Rahmadani. In this study, 95% influenced students' critical thinking in science learning on heat material in group V of SDN 77, Central City, Gorontalo[18].

Based on the results of the research that have been described, it can be concluded that the application of the Problem Based Learning learning model and technology-based learning media, such as Augmented Reality , has a significant positive impact on improving students' Critical Thinking. This research is relevant to the research conducted, where the use of the Problem Based Learning model with the help of Augmented Reality media in Computer Engineering and Network subjects has been proven to significantly improve students' Critical Thinking .

IV. CONCLUSION

This research proves that the Problem Based Learning model assisted by Augmented Reality media has a positive and significant effect on the critical thinking abilities of Computer and Network Engineering students at SMK Negeri 1 Bukittinggi. The average post-test score for the experimental class (70.31) was higher than the control class (63.43), with an influence level of 73.65% in the medium category. The statistical test results show a sig (2-tailed) of 0.005 and the calculated t (2.942) is greater than the t table (1.670), so this method is proven to be effective.Future research could explore other variables that might influence the effectiveness of the Augmented Reality-based Problem Based Learning model, such as learning motivation or problem solving skills.

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