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Application of Problem Based Learning Model Assisted by Augmented Reality Media to Improve Students' High Order Thinking Skills

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Abstract – *This study aims to determine the increase in the level of students' High Order Thinking Skills (HOTs) after being given learning with a Problem Based Learning (PBL) model assisted by Augmented Reality (AR) media. This study was a quantitative research using Pre-Experimental method in the form of one group pretest-posttest design. The sample of this study was 31 students of class X IPA SMA Negeri 9 Bengkulu City. The research data was collected through 3 stages, namely the pretest, treatment using the Problem Based Learning model assisted by Augmented Reality media, and the post-test. The research data was processed with the help of statistical software package for social sciences (SPSS) 20. Data analysis was carried out through Statistical Descriptive Test, then Data Normality Test with Klomogorov Smirnov. The results of data analysis showed that the data sample was normally distributed with a significance value of 0.29, that is more than 0.05, and further data analysis used the Parametric Paired Pample T-test. Based on the data analysis, it was concluded that Ha was accepted with a sig. 2 tailed 0.00 is less than < 0.05. Therefore, it can be concluded that there is an increase in the level of students' High Order Thinking Skills after the implementation of the problem-based learning model assisted by augmented reality media with an N-gain value of 0.36 in the category of medium level of improvement.*

Keywords: *augmented reality; high order thinking skills; problem based learning*

I. INTRODUCTION

The 21st century is a new era where the progress of science and technology has grown rapidly. The evolution of technology combined with an adequate pedagogical foundation has changed the face of education (Nincarean et al., 2013). In the current era of education, students have taken an important role in the learning process. Students are required to have life skills, where they must be skilled in using technology as well as creative and skilled in learning (Anggraeni & Sole, 2018). One of the skills requirements that must be possessed by students today is the ability to think at a higher level. According to (Hartini et al., 2021) the cognitive domain is divided into six levels, namely: *Lower Order Thinking Skills* namely

C1-C3 which consists of remembering, understanding, and applying, as well as *High Order Thinking Skills* namely C4-C6 which consists of analyzing, evaluating, and creating. In higher order thinking skills, students with knowledge above the average score are much better than students with a scientific perspective below the average (Wilujeng & Suliyanah, 2022).

Physics lessons are a branch of complex science (Alfiah & Dwikoranto, 2022). In relation to this complex nature, it requires students to be able to develop and use higher order thinking skills in learning it. Skills in higher order thinking which is defined as the ability to think in a more complex and comprehensive manner with a view to obtaining a solution to a problem (Witri et al., 2019). The lesson has been considered a frightening lesson for most students, who imagine that physics is a formula and a series of numbers that will be difficult to understand. As a result, students have difficulty interpreting what they learn. The use of irrelevant learning models and supporting media is one of the causes of relatively low student learning outcomes. As mentioned in research that (Khalid et al., 2016) conducted, the use of conventional models without being supported by interesting learning media in the learning process, makes the level of students' learning motivation low towards physics subjects so that students' thinking skills are also low.

Based on the results of observations at SMA Negeri 9 Bengkulu City, the students' thinking skills, especially in physics lessons at the school, are in low category. Based on the results of an interview with a physics teacher, it was stated that the limited use of physics supporting media caused students to not see it in using their abilities. The use of conventional learning models in every lesson is the cause of low understanding of physics lessons. Physics with all the complexity of the material requires something in the learning style in class, especially the learning models and media used, so that during the learning process students can use and can improve higher-order thinking skills. In the process of learning physics, it is very much needed in the media used and supported by learning models that can improve students' *High Order Thinking Skills* abilities.

The use of problem based learning models is one of the many learning steps that are in line with the scientific approach (Asuri et al., 2021). A study conducted by (Herman, 2007) revealed that with *Problem Based Learning* model, the learning activities of students will be more prominent than the activities that should be carried out by teachers/lecturers/educators. Using this learning model will provide the same experience for students when they are being in different disciplines relevant to the characteristics of science learning. In the problem-solving process in this model, students are required to be able to construct

knowledge and develop problem-solving skills and skills to learn *self-directed* when looking for a solution to a problem (Andriani, 2016). This learning model has been widely recommended for use in learning as mentioned in research (Sulistyani, 2018), where the *Problem Based Learning* model is good enough to be applied in a lesson, especially applied to physics learning, will facilitate students in improving their High Order Thinking Skills abilities. to better understand the concepts of physics. This *Problem Based Learning* model consists of several stages carried out in the learning process: (1) identifying a problem; (2) designing problem solving; (3) carry out investigations related to problem solving; (4) report the results of investigations in problem solving; (5) analyzing the processes that take place in problem solving (Anisa et al., 2020). In (Royantoro et al., 2018), it is stated that the use of the *Problem Based Learning* model carried out in the classroom has had a significant impact on increasing students' High Order Thinking Skills.

Education in Indonesia in the 4.0 revolution era is *online learning* (Katili et al., 2018). It was proven after the pandemic conditions that forced even all students in Indonesia to carry out learning activities boldly using *smartphones*). The data shows that 81% more students do their homework using *smartphones* and 67% more students use *smartphones* as a tool in the learning process in the classroom. The use of *smartphones* with internet allowance for educational purposes has increased many times among students (Kumar, 2011).

Augmented Reality is a direct and indirect view of an object, displayed virtually with some additional useful information to help users interact with the real world. Augmented Reality does not completely contain virtual reality that is displayed in the real world, but only as a facility used to add or complete the perception of reality (Carmigniani et al., 2011). Augmented Reality media is displayed on physical material, both two-dimensional and three-dimensional, demanding visualization from the user. Existing material will be able to be displayed in *real time*, so that it will attract students' understanding and motivate learning (Ramadhan & Hardianto, 2020). In using Augmented Reality media, it is hoped that it can help students in visual understanding of 3-Dimensions forms from the application of physics material and help parents and teachers make learning more interesting and practical.

Based on the description above, the purpose of this study was to determine the increase in the *High Order Thinking Skills* level of students after the implementation of learning using the *Problem Based Learning* model assisted by *Augmented Reality* media.

II. METHODS

This research is a quantitative *Pre-Experimental* study, with a *One Group*

Pretest Post-test Design scheme (Fraenkel et al., 2006).

Table 1. Schematic of Research Design

One Group Pretest-Posttest Design

O	***X***	***O***
Pretest	*Treatment*	*Posttest*

The research design in table 1 is the provision of pretest questions to measure the initial level of *High Order Thinking Skills* that students have before being given treatment. Then the treatment was followed by the treatment in the form of application of learning using the *Problem Based Learning* model assisted by Augmented Reality media in the straight motion kinematics sub material. Finally, the students were given post-test questions with the same category and questions on the pretest, to re-measure the High Order Thinking Skills level of the students. The tests given at the beginning and end of learning aimed to see how much increase in the level of *High Order Thinking Skills* students receive.

The research sample was taken by using a *Purposive Sampling* technique considering that the selected group of students was able to provide representative information to assist the results of this study than other class groups. The research sample used was 31 students from class X IPA 1 of SMA Negeri 9 Bengkulu City. This research was carried out in August 2022.

This study focuses on the application of *Problem Based Learning* model, which is used to measure the improvement of higher order thinking skills of students at SMA Negeri 9 Bengkulu City. The instruments during this research were in the form of learning implementation sheets, test sheets (*pretest* and *post-test)* and expert test validation sheets, as well as *Augmented Reality* learning media in the Asemblr application. The instrument in this study is to measure the ability of students to solve a problem and the ability of students to think at higher levels. The questions on the test sheet presented to students for the pretest and post-test are the same. The questions given consist of 4 description questions with 2 question of categories C4, 1 question of category C5, and 1 question of category C6; each question category has been validated by experts by 2 teachers from SMA Negeri 9 Bengkulu City. who is an expert in the field of physics learning.

The *Augmented Reality* media used is assisted by the Asemblr application. The display on the Asemblr application is interactive, where students must scan the barcode that has been prepared in advance, then direct the *smartphone* camera to an empty object so that the visualization of straight motion material in the form of components of cars, buildings, writing, images and videos that have been provided can be accessed instantly, and make learning more interesting for students. The *Augmented Reality* media used is able to visualize abstract objects as if they are real and can be

displayed around us so that through this *Augmented Reality* technology media, if used as a learning medium, it will be able to help the learning process in the classroom.

The stages of the research carried out are divided into 3 parts, namely: (1) The preparation stage starts from the background analysis of the problem in the form of observations and interviews, followed by the selection of research samples, then preparation of learning tools and instruments; (2) The implementation stage is giving pretest questions, doing *Problem Based Learning* model learning assisted by Augmented Reality media, then giving post-test questions. Data collection techniques are carried out in the implementation stage; (3) The final stage is carried out after obtaining the result data obtained during the research. The process of processing and analyzing cognitive data is carried out on the research data obtained.

Cognitive data analysis techniques were processed using the application of *Software Statistical Package For Social Sciences* 20. Data processing went through several stages, namely: Statistical descriptive test for the presentation of the combined data that had been obtained, Descriptive testing is carried out to describe or describe research data presented in the form of data groups (Asdar et al., 2020). Normality Test is used to test whether the variables are normally distributed or not. The *Kolmogorov Smirnov test* used in this Normality Test, has a sample data reference tested > 30 and the total samples in both data (pretest-posttest) are the same. In this test, the sample is standardized and compared with the standard normal distribution (Quraisy, 2020). Hypothesis testing was carried out using *the Parametric Statistical Test*, namely *the Paired-Samples T-test* on normally distributed sample data. With guidelines for decision making according to (Aulannisa et al., 2021) as follows:

- If the significance value (Sig.) (2-tailed) <0.05, then Ho is rejected and Ha is accepted.
- If the significance value (Sig.) (2-tailed) > 0.05, then Ho is accepted and Ha is rejected.

Meanwhile, for data that is declared not normally distributed, the non-parametric test, namely *the Wilcoxon test*, will be carried out in a hypothesis test in accordance with the theory of (Sugiyono, 2015) which states that if the data tested is not normal, *the parametric statistical test* cannot be used so that the hypothesis test is carried out with *non-parametric statistical test.* The final stage is calculating and categorizing the Gain value through the N-Gain Test. With reference to the distribution of N-gain scores in table 2.

Table 2. Category of N-Gain

N-Gain Value	Category
$g > 0.7$	Tall
$0.3 \leq g \leq 0.7$	Currently
$g < 0.3$	Low

The N-gain value of the students' pretest-posttest scores was calculated using the g factor formula according to Meltzer (Latief et al., 2014).

$$N\ Gain = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score}$$

(Meltzer in Latif, 2014)

In the N-Gain calculation formula, the total score for each question is the ideal score that becomes the divisor in calculating the N-Gain value. Thus, by using the formula, the N-Gain value will be obtained according to the reference category for the distribution of scores in table 2.

III. RESULTS AND DISCUSSION

In this study, the data obtained from the research that has been carried out are as follows.

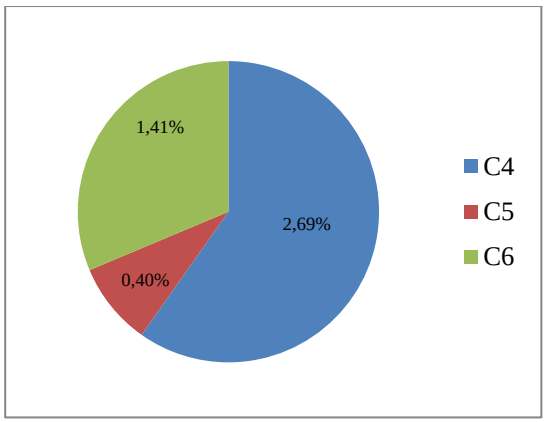

Figure 1. Average Completion of Pretest Questions per Category

Figure 1 shows that the students can complete the pretest questions per category correctly are 6.12% of the total 100% obtained, each category earned 2.69%, 0.40%, and 1.41% for category C4, C5, and C6, respectively.

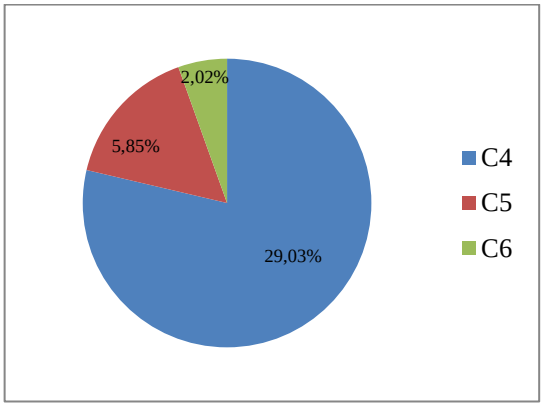

Figure 2. Average of Pretest Question Result per Category

In Figure 2, the students who can complete the post-test correctly are 39.90% of the total 100%, where category C4, C5, and C6 earned 29.03%, 5.85%, and 2.02%, respectively.

The pretest and post-test scores of students after and before being given treatment are presented cumulatively through the statistical descriptive test in table 3.

Table 3. Statistical Descriptive Test

Description	*Pretest*	*Post-test*
The highest score	20	70
Lowest Value	0	20
Sum	205	1275
Average	6.61	41.13
Number of Students	31	31

In the table 3, the total pretest scores obtained by students are much smaller than the post-test scores. While in the post-test, the total score was 1275, 6 times greater than the total score of the pretest. Thus, students who complete this test are declared absent. Then the acquisition of the average score of

students before receiving treatment in the form of applying the *Problem Based Learning* model, is far below the criteria for the lowest score to be declared to have achieved completeness in a lesson. In the table 3 the difference in the average score after the treatment is carried out is higher than the average score before the treatment is carried out at 41.13.

The normality test is the Kolmogorov Smirnov test. The basis for making normality test decisions is based on the following (Pratama & Permatasari, 2021).

• If the value of sig. > 0.05, the data is normally distributed.
• If the value of sig. <0.05, the data is not normally distributed.

Normality test is carried out as part of the prerequisite test or assumption test of data analysis before proceeding to the statistical analysis test stage for hypothesis testing, the research data obtained must be tested for normality of distribution.

Table 4. Normality Test One Sample Kolmogorov-Smirnov Test

One Sample Kolmogorov- Smirnov Test		
	Sig. (2-tailed)	**Decision**
Unstandardized Residual *Pretest-Posttest*	0.29	Normal Distributed Test

In the table 4, the output from the Kolmogorov Smirnov normality test is obtained. The residual unstandardized sample data tested is stated to be normally distributed with sig. 0.29. In accordance with the (Pratama & Permatasari, 2021) criteria above, if the significance value is greater than > 0.05, then the sample data is declared to be normally distributed and can proceed to the data analysis stage of Assumption Testing in the form of hypothesis testing. Testing the selected hypothesis if the data is normally distributed, namely by using parametric statistical tests *(Paired Sample T-Test).* Tests with this method are used to assess the effectiveness of the treatment after it is given, which is indicated by the difference in the average value between after and before it is given.

Table 5. T Test

Paired Samples Test		
	Sig. (2-tailed)	**Category**
Pretest scores –Posttest scores	0.00	Sig.< 0,05

Based on the t-test output obtained in table 5, the sig value is obtained. of 0.00. The conclusion in this case is based on the reference in (Anuraga et al., 2021) the sample results provide an indication of supporting the results of the sig hypothesis test. *(2-tailed)* is less than < 0.05, then the hypothesis is accepted. Meanwhile, if the sample results show contradictory indications, sig. *(2-tailed)* is greater than > 0.05, then the hypothesis is rejected. Thus in table 5 obtained the value of Sig. < 0.05, it can be concluded that the initial

hypothesis value (Ho) there is no difference in the High Order Thinking Skills value of students before and after being given treatment is declared rejected, and the alternative hypothesis value (Ha) is declared accepted because there is a difference between before being given treatment and after being given treatment on the High Order Thinking Skills value of participants educate.

Table 6. Results of N-Gain

Category	Average	N Gain	Description
Pretest	6.61	0.36	Currently
Posttest	41.13		

Based on table 6, the N-gain value with an ideal test score of 100, the N-Gain value is 0.36. This value, when viewed again in table 2, is in the range of scores of 0.3 g 0.7. Thus, the N-Gain value obtained is stated in the medium category.

In addition to the presentation of quantitative data obtained by researchers in the discussion above, researchers found several studies in the form of relevant journal sources that support as a reference source of data. In a study conducted in one class at SMA Negeri 1 Kembang, it was stated that there was a significant improvement in the cognitive domain of students after the implementation of learning with the Problem Based Learning model assisted by a virtual PhET laboratory in the classroom. Supported by an increase in several aspects of students' *High Order Thinking Skills* consisting of critical thinking, creative thinking, and problem solving, an N-Gain score of 0.56 was obtained with a moderate improvement category (Alfiah & Dwikoranto, 2022).

The problem-based research conducted by (Royantoro et al., 2018) was able to support the results of the research conducted where it was stated that there was a significant increase in the higher-order thinking ability of students who received learning using the Problem Based Learning model compared to those who only did learning. using the conventional model. After getting good results in the use of the problem-based learning model, the model can be used as an alternative learning model at SMA Negeri 1 Manokwari. This research is also supported by several research results mentioned in (Mayasari & Adawiyah, 2015) where *Problem Based Learning* is proven to be able to develop student's skills in critical and analytical thinking and exposes students to be able to solve problems in real life.

Based on the results of the analysis of the data obtained, it can be concluded that the problem-based learning model can improve students' *High Order Thinking Skills* in physics class X IPA 1 SMA Negeri 9 Bengkulu City where the results show an increase in the High Order level Thinking Skills of students before and after learning. The difference in the values obtained was quite significant between the initial test (*pretest)* and the final test (*post-test)* with the moderate gain category in the value range of 0.36. The results of this study are in accordance with what was conducted by

(Alfiah & Dwikoranto, 2022) which states that the use of the *Problem Based Learning* learning model plays a role in increasing each aspect of students' *High Order Thinking Skills* where the use of this model is able to stimulate students' minds to think to a higher level.

The problem based learning model used in this study is an effective and suitable learning model in physics lessons as mentioned in the research (Khoiri et al., 2017) PBL models are effective in increasing HOTs, complexity, and learning motivation, as well as students' flexibility. The application of this model is an alternative choice of learning methods for teachers when teaching in class. With the help of qualified learning media such as Augmented Reality, the use of this Problem Based Learning learning model will be able to further arouse and improve the skills possessed by students to the maximum. The implementation of this model is effective for students because it requires students to be able to exchange ideas and opinions between fellow students and teachers. This model not only makes students able to find solutions to a problem but is also able to make students more critical and creative in expressing the contents of their minds. Supported by the results of research from (Hasmiati et al., 2018) which revealed that the PBL model was able to facilitate the development of students' creative thinking skills in the learning process in the classroom, so from the results of the above description, it is hoped that this *problem-based learning* model can be an alternative and can be applied by teachers in classroom learning.

IV. CONCLUSION AND SUGGESTION

Based on the statistical results of the research data obtained, the results of hypothesis testing Ha are accepted and Ho is rejected, and it can be concluded that there is an increase in the level of High Order Thinking Skills in students with the category of improvement level being moderate and the N-gain value of 0.36. The increase in the level of High Order Thinking Skills can be seen after the students received learning treatment using the Problem Based Learning model assisted by *Augmented Reality* media. Thus, it can be concluded that the provision of treatment using the *Problem Based Learning* learning model assisted by *Augmented Reality* media in class X IPA 1 resulted in a significant increase in the increase in the pretest-posttest scores of students at SMA Negeri 9 Bengkulu City.

In this study, the category of the increase in High Order Thinking Skills value was still relatively small because it was only 0.06 higher in the medium category value range, which was 0.30. Therefore, further research is needed, by further developing interesting and more interactive media for students so that the level of improvement obtained is greater than before.

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