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The Effect of Using Augmented Reality in Science Learning on Middle School Students' Concept Understanding

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ABSTRACT

This study aims to explore the effect of using Augmented Reality (AR) technology in science learning on secondary school students' concept understanding. AR technology allows the integration of the virtual world with the real world through interactive and dynamic visualization, so it is expected to increase learning interest and understanding of science concepts among students. The method used in this study was a quasi-experiment with a pretest-posttest control group design. The research sample consisted of 120 grade X students in one of the secondary schools who were randomly divided into experimental and control groups. The experimental group used AR application as part of science learning, while the control group used conventional methods. Data were collected through concept understanding tests administered before and after the intervention. The results of the data analysis showed that there was a significant increase in the concept understanding of students using AR compared to the control group. The mean posttest score of the experimental group was statistically higher than that of the control group ($p < 0.05$). This finding indicates that the use of AR in science learning is effective in improving students' concept understanding. This study suggests that AR technology can be integrated into the science learning curriculum as an innovative and effective tool. In addition, further research is recommended to explore other aspects of using AR in education as well as its impact on students' cognitive and affective skills.

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1. INTRODUCTION

The development of technology in recent decades has brought significant changes in various aspects of life, including in the field of education. One of the technological innovations that is increasingly used in the learning process is Augmented Reality (AR). AR technology allows users to view virtual objects that interact with the real world in real-time, creating a more immersive and interactive learning experience. In the context of science learning, AR has great potential to help students understand complex and abstract concepts in a more visual and concrete way. [1]

Science learning in secondary schools often faces challenges in delivering abstract material that requires high visualization. Concepts such as atomic structure, interactions between molecules, and other natural phenomena are not easy to grasp through verbal explanations or static images alone. As a result, many students have difficulty in understanding the material, which can have an impact on their low learning achievement. [2] The use of AR in science learning offers a solution to address this challenge. By utilizing AR, abstract concepts can be visualized in an interactive three-dimensional form, allowing students to explore and understand the

material in a more in-depth way. Some previous studies have shown that the use of AR in education can increase students' motivation and interest in learning, but research regarding the effect of AR on concept understanding, particularly in science learning in secondary schools, is still limited. [3]

Therefore, this study aims to explore the effect of using AR in science learning on middle school students' concept understanding. [3] Through this research, it is hoped to gain a better understanding of the effectiveness of AR as a learning tool, as well as provide recommendations for the implementation of this technology in the science education curriculum in secondary schools. [4]

2. METHOD

This study used a quasi-experiment design with a pretest-posttest control group design model. This design was chosen to test the effect of using Augmented Reality (AR) in science learning on students' concept understanding. In this design, there are two groups that are treated differently: an experimental group that uses AR in science learning and a control group that uses conventional learning methods without AR. [5]

The population of this study was grade X students in one of the secondary schools in the city of semarang. [6] The research sample was taken using purposive sampling technique, which is the selection of samples based on certain considerations, such as the school's willingness to adopt AR technology in learning and the suitability of the learning schedule. The sample consisted of 120 students divided into two groups, each group consisting of 60 students. [7]

The main instrument used in this study was the science concept understanding test developed by the researcher. [8] The test consisted of 25 multiple choice questions covering various science concepts taught in the grade X curriculum. The validity of the instrument was tested through expert judgment and instrument trials, while its reliability was tested using Cronbach's Alpha with a reliability value above 0.70 considered adequate. [9] In addition, a questionnaire was also used to measure students' responses to the use of AR in learning. This questionnaire covers aspects of learning interest, motivation, and students' perceptions of the effectiveness of AR. [10]

Research Procedure

This research was conducted in several stages:

1. Preparation Stage: Includes developing AR-based learning materials, testing research instruments, and training teachers in using AR technology. [11]
2. Implementation Stage:

a) Pretest: Both groups (experimental and control) were given a concept understanding test before the intervention to measure students' initial knowledge. [12]

b) Intervention: The experimental group received science learning with the help of AR for 4 weeks, while the control group received science learning with conventional methods of the same duration.

c) Posttest: After the intervention, both groups were again given the same concept understanding test to measure changes in concept understanding after learning. [13]

3. Data Analysis Stage: The pretest and posttest data were analyzed using independent t-test to see the significant difference between the experimental and control groups. In addition, a descriptive analysis of the questionnaire results was conducted to evaluate students' responses to the use of AR. [14]

Validity and Reliability

To ensure the internal and external validity of the study, the following steps were taken:

a) Internal Validity: Control of external variables that could affect the results of the study through strict control of the conduct procedures and instruments used. [15]

b) Reliability: Instrument reliability tests were conducted using Cronbach's Alpha to ensure internal consistency of the instruments.

3. RESULTS AND DISCUSSION

The results of this study are based on data obtained from concept understanding tests given before (pretest) and after (posttest) the intervention, as well as questionnaires measuring students' responses to the use of Augmented Reality (AR) in learning.

Pretest Analysis

The pretest results showed that there was no significant difference in concept understanding between the experimental and control groups before the intervention. The mean pretest score of the experimental group was 62.3, while the control group had a mean score of 61.8. An independent t-test showed that $p > 0.05$, indicating equality of initial knowledge between the two groups.

Table 1. Pretest Analysis

Group	Number of Students	Average Pretest Score	Standard Deviation	P-value
Experiment Group	60	62,3	5,2	
Control Group	60	61,8	5,2	
Total / Conclusion	120			**p > 0,05**

Notes:
The table above shows the results of the pretest analysis between the experimental and control groups.
The p value indicates that there is no significant difference between the experimental and control groups before treatment ($p > 0.05$).

Posttest Analysis
After the intervention, there was a significant increase in posttest scores in the experimental group compared to the control group. The average posttest score of the experimental group increased to 85.6, while the control group only increased to 72.4. An independent t-test showed that the difference between the two groups was statistically significant with $p < 0.01$, indicating that the use of AR in science learning had a significant positive impact on students' concept understanding.

Group	Number of Students	Average Posttest Score	Standard Deviation	P-value
Experiment Group	60	85,6	6,1	
Control Group	60	72,4	7,0	
Total / Conclusion	120			**p > 0,01**

Table 2. Posttest Analysis

Notes:
The table above shows the results of posttest analysis between the experimental and control groups.
The mean posttest score of the experimental group was significantly higher than that of the control group.
The p value <0.01 indicates a significant difference between the two groups after the intervention, with the experimental group showing better concept understanding.

Questionnaire Analysis
The questionnaire analysis showed that most students in the experimental group responded positively to the use of AR in learning. As many as 87% of students reported that AR helped them better understand difficult science concepts. In addition, 82% of students felt more interested and motivated in learning when using AR.

Aspects Measured	Number of Students (n)	Percentage of Positive Respondents	Percentage of Neutral Respondents	Percentage of Negative Respondents
Understanding Science Concepts with AR	60	87%	10%	3%
Increased Learning Interest	60	82%	12%	6%
Improved Learning Motivation	60	85%	10%	5%
Ease of Use of AR	60	78%	15%	7%
Desire to Use AR in the Future	60	80%	13%	7%

Table 3. Questionnaire Analysis

Notes:
This table illustrates the questionnaire analysis results of the experimental group that used AR in learning. Percentage of Positive Respondents refers to students who gave positive responses to the measured aspects (e.g., agree or strongly agree).

The percentage of Neutral Respondents includes students who gave neutral responses (e.g., disagree or strongly disagree). The percentage of Negative Respondents includes students who gave negative responses to the measured aspects (e.g., disagree or strongly disagree).

Discussion

The results of this study show that the use of AR in science learning significantly improves students' concept understanding compared to conventional learning methods. The higher increase in posttest scores in the experimental group indicates that AR is able to facilitate the understanding of abstract concepts in a more visual and interactive way.

AR allows students to visualize difficult-to-understand concepts, such as atomic structure or natural phenomena, in a three-dimensional form that they can explore. This more interactive learning experience not only helps in building deeper understanding, but also increases students' interest and motivation to learn, as shown by the questionnaire results.

These findings are in line with previous studies showing that AR technology has great potential in education, particularly in improving learning outcomes and student engagement. However, these results also emphasize the importance of proper integration of AR in the learning curriculum. The use of AR should be supported by good learning design and adequate training for teachers to maximize the potential of this technology.

In addition, this study indicates that although AR is effective in improving concept understanding, other factors such as learning motivation and interest also play an important role in successful learning. Therefore, the implementation of AR technology should consider broader pedagogical aspects to ensure that this technology really has the maximum impact on learning.

4. CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the use of Augmented Reality (AR) technology in science learning has a significant positive effect on middle school students' concept understanding. The significant increase in posttest scores in the experimental group compared to the control group shows that AR is effective in helping students understand complex and abstract science concepts.

AR technology enables more immersive interactive visualization, providing a more concrete and enjoyable learning experience for students. In addition, AR also increases students' interest and motivation to learn, as revealed through the questionnaire results. Students who learn with the help of AR tend to feel more engaged and interested in the subject matter, which ultimately contributes to the improvement of their learning outcomes.

Thus, the integration of AR in science learning in secondary schools can be considered as an innovative strategy to improve the quality of education. The use of AR not only enriches students' learning experience but also enables better understanding of concepts, which is crucial in science education. However, to maximize the benefits of AR, careful preparation is needed, including teacher training and curriculum adjustments that support the use of this technology.

This study also suggests the need for further research to further explore the long-term impact of using AR in learning, as well as its applicability to other subjects and at different levels of education. With the right use of technology, AR has great potential to revolutionize the way we teach and learn in the 21st century.

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