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Effectiveness of Using Android-Based Augmented Reality (AR) Media to Enhance Students' Learning Motivation in Science Lessons

Wargo Silanto[1*], Abdul Muis[1], Waris[1], Indah Kharismawati[1]

[1] Universitas PGRI Argopuro Jember, Jember, Indonesia.

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Corresponding Author:
Wargo Silanto
wargo.goel@gmail.com

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Abstract: This study investigates the effectiveness of Android-based Augmented Reality (AR) in enhancing students' learning motivation in science. Using a quasi-experimental design, two groups were involved: a control group, which was taught using conventional methods, and an experimental group, which used AR media. The research sample consisted of 42 high school students, divided into two groups of 21 each. Data were collected through pretests and posttests, as well as a motivation questionnaire adapted from the ARCS model (Attention, Relevance, Confidence, Satisfaction). The results revealed a significant difference in motivation between the two groups, with the experimental group showing an average posttest score of 84.11, compared to 61.72 in the control group. The t-test showed a significant difference ($p = 0.001$), and N-gain analysis demonstrated that the experimental group had a higher N-gain (77.59%) compared to the control group (56.56%), indicating the effectiveness of AR. Additionally, the experimental group showed significant improvements in attention and satisfaction. This study concludes that Android-based AR is an effective tool for increasing student motivation in science, and recommends further research on its use in other subjects with larger samples.

Keywords: Augmented reality; Effectiveness; Learning motivation; Science lessons

Introduction

The technological revolution that has taken place over the past few decades has transformed various aspects of human life, including the way we acquire, process, and understand information. In the context of education, the application of digital technology has opened up great opportunities to create more effective, engaging, and relevant learning environments that meet the needs of 21st-century students. One of the rapidly developing technologies that offers significant innovation in the field of education is Augmented Reality (AR). This technology enables the integration of virtual elements into the real world in real-time, creating an immersive and interactive learning experience (Safira et al., 2022).

On the other hand, science education is one of the fields that greatly benefits from the integration of technologies such as AR. Science subjects often contain abstract concepts that are difficult for students to understand if only conveyed through conventional methods, such as lectures or textbooks. For example, understanding the structure of atoms, the carbon cycle, or ecosystem interactions requires strong visualization so that students can comprehend the relationships between components in a comprehensive manner. Traditional teaching methods are often insufficient to facilitate this understanding, leading students to lose interest in learning, which ultimately affects their

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motivation to learn (Chang et al., 2022; Feng et al., 2024; Jin et al., 2021; Kang et al., 2018).

Learning motivation itself is one of the most important factors in the success of education. According to Agusta (2022), learning motivation can influence how students interact with learning materials, teachers, and their learning environment. Motivated students tend to be more engaged in learning, have a high level of curiosity, and demonstrate better academic performance. Therefore, one of the key focuses in educational innovation is to enhance students' learning motivation, especially in subjects considered difficult, such as science.

The application of AR in science education not only allows students to see and interact with visual simulations of complex concepts but also provides a more engaging and enjoyable learning experience. Android-based AR technology, which is compatible with mobile devices, has great potential to be widely adopted in various educational settings. This is because Android devices are relatively affordable and easy to use, even in areas with limited technological infrastructure. Previous studies have shown that AR-based learning media can increase student engagement, strengthen conceptual understanding, and provide a more contextual learning experience compared to traditional methods (Aini & Zulfadewina, 2024).

The use of AR as a learning medium has the potential to enhance students' learning motivation in science subjects. A study by Tania et al. (2023) shows that the application of AR in learning can increase students' attention and engagement levels, which in turn can boost their motivation to learn. Android-based AR media is becoming increasingly popular due to its higher accessibility, making it easier to implement in various schools, even in areas with limited resources. The application of Android-based AR in science education is expected to create a more engaging learning environment, improve conceptual understanding, and, most importantly, enhance students' learning motivation.

Several previous studies have shown promising results regarding the use of AR in science education. A study by Uno (2024) found that the use of AR in science learning could increase student engagement, strengthen conceptual understanding, and improve learning outcomes. Another study by Arifin et al. (2020) revealed that AR technology is effective in helping students understand complex concepts in STEM (Science, Technology, Engineering, and Mathematics) fields. A study by Aditya et al. (2022) found that the use of AR in science education could enhance student engagement, strengthen conceptual understanding, and make it easier for students to grasp abstract material. Further research by Aminudin et al. (2024) showed that Android-based AR media can enhance students' learning motivation in science education and provide a more engaging and interactive experience. A similar finding by Zulfahmi et al. (2020) stated that AR technology can improve learning outcomes and motivate students to be more active in science learning. A study by Mujiono et al. (2021) added that the implementation of Android-based AR has the potential to increase students' interest and motivation, as it leverages technology that is familiar to students' daily lives. However, there is still limited research specifically examining the impact of Android-based AR media on students' learning motivation in science education, especially at the high school level.

However, the adoption of new technologies like AR requires empirical evaluation of its effectiveness. Not all technological innovations can directly enhance student motivation or learning outcomes (Rofi et al., 2023). Therefore, it is important to examine how Android-based AR can affect students' learning motivation, especially in the context of science education. This study aims to evaluate the effectiveness of using Android-based AR media in improving students' learning motivation in science education. By comparing a group of students using AR media with a group learning through conventional methods, this research is expected to provide empirical evidence on the benefits of AR technology in science education.

Furthermore, this study also aims to provide insights to educators, educational technology developers, and policymakers on how to leverage new technologies to create more relevant and meaningful learning experiences for students. The results of this research are expected to serve as an important reference in the development of technology-based teaching methods in the future, particularly for science subjects that require high levels of visualization and interactivity.

Method

This study is Quasi-Experimental research that involves two sample groups: the control group and the experimental group (Hastjarjo, 2019). The control group consists of a class that does not receive the treatment of learning using Android-based Augmented Reality, while the experimental group consists of a class that is taught using Android-based Augmented Reality. In this design, both the control and experimental groups are compared, with the groups being selected through purposive sampling. The sample in this study consists of 42 students from a high school in Jember, with 21 students in the control group and 21 students in the experimental group.

The instruments used in this study consist of two types: test instruments and non-test instruments. The

test instruments include multiple-choice questions consisting of 8 items and essay questions consisting of 5 items. The non-test instrument consists of a learning motivation questionnaire with 20 items. Both the test items and the questionnaire given before and after the treatment are the same. The learning motivation questionnaire was adopted from Setyowati et al. (2022), then modified based on the ARCS motivation theory (Attention, Relevance, Confidence, and Satisfaction).

The data collection techniques used are pretest and posttest, as well as the administration of the learning motivation questionnaire. The steps taken to collect the data are: (1) administering the pretest and initial motivation questionnaire to students who did not receive the ARCS model treatment with Android-based Augmented Reality media, (2) administering the posttest and final motivation questionnaire to students who received the ARCS model treatment with Android-based Augmented Reality media, (3) conducting an Independent Sample t-Test to determine whether there are differences in learning motivation between the experimental and control classes, and (4) performing an N-gain percentage test to determine the effectiveness of Augmented Reality media on students' learning motivation.

Result and Discussion

The results obtained are presented in the Descriptive Data Recap of students' learning motivation in science lessons, which is shown in Table 1.

Table 1. Learning Motivation of the Experimental Group and Control Group

Group	Average Pretest	Average Posttest
Control	42.61	61.72
Experimental	46.39	84.11

Table 1 shows the average pretest score of students' learning motivation in the control group, which is 42.61, and the average posttest score of students' learning motivation in science lessons in the control group, which is 61.72. Meanwhile, the average pretest score of students' learning motivation in science lessons in the experimental group is 46.39, and the average posttest score of students' learning motivation in the experimental group is 84.11.

A hypothesis test using the t-test was conducted to determine whether there is a difference in students' learning motivation in science lessons between the control group and the experimental group. If the significance value (sig) is greater than 0.05, there is no difference in students' learning motivation; otherwise, there is a significant difference in learning motivation between the control and experimental classes.

Table 2. Results of the Pretest t-Test

	Sig (2-tailed)
Learning Motivation	0.001

Based on the results of the Independent Sample T-Test, which is the hypothesis test used in this study, the Sig. (2-Tailed) value of the t-test is 0.001, which is less than 0.05. Therefore, Ho is rejected, and Ha is accepted, indicating that there is a difference in students' learning motivation between the control group and the experimental group. This means that Android-based augmented reality media is effective in increasing students' learning motivation in science lessons.

The N-gain test is used to assess the effectiveness of using Android-based AR media in science lessons. Table 3 shows the N-gain percentage results for students' learning motivation obtained through SPSS testing as follows:

Table 3. Results of the N-gain Test

	Group	Mean	Std. Error
N-gain Percentage	Control	56.5611	1.92021
	Experimental	77.5911	1.64531

Table 3 shows the results of the N-gain percentage test, with an average N-gain percentage of 77.59% for the experimental class, which falls under the effective category, while the average N-gain percentage for the control class is 56.56%, which falls under the moderately effective category.

$$effectiveness = \frac{77.59}{56.56}$$

$$effectiveness = 1.37$$

Based on the effectiveness testing criteria for students' learning motivation in science lessons, the effectiveness test result is 1.37 > 1, which means there is a difference in effectiveness, with learning using Android-based AR media being more effective than learning with the conventional model.

The recapitulation of the percentage for each indicator on the students' learning motivation questionnaire for both the experimental and control groups is presented in Table 4.

Based on the table 4, it is observed that in the experimental class, the indicator with the highest percentage is Satisfaction, categorized as Good, and Attention, categorized as Very Good. Similarly, in the control class, the highest percentage is also found in the Satisfaction indicator, categorized as Good, and Attention, categorized as Very Good. This indicates that the use of Android-based AR media provides a more engaging, motivating, and satisfying learning experience compared to conventional methods.

Table 4. Recapitulation of the Learning Motivation Questionnaire Percentage Results for the Experimental and Control Classes

Motivation	Item	Experimental Group		Control Group	
		%	Criteria	%	Criteria
Initial Motivation	A	48	Fairly Good	39	Fairly Good
	R	56	Fairly Good	56	Fairly Good
	C	47	Fairly Good	47	Fairly Good
	S	63	Good	68	Good
Final Motivation	A	91	Very Good	85	Very Good
	R	88	Very Good	80	Good
	C	89	Very Good	73	Good
	S	87	Very Good	78	Good

The results of this study indicate that the use of augmented reality (AR)-based learning media in science education significantly improves students' learning motivation compared to conventional teaching methods. This is reflected in several findings, such as the increase in average motivation scores, hypothesis testing results, effectiveness based on N-gain tests, and analysis of motivational indicators. Overall, the use of AR technology is shown to create a more interactive, engaging, and relevant learning environment that meets the needs of students in the digital age.

Based on the data recap, the average pretest score for learning motivation in the control group was 42.61, which increased to 61.72 on the posttest. Meanwhile, the experimental group using AR-based Android media experienced a more significant increase, from an average pretest score of 46.39 to 84.11 on the posttest. These results show that although the conventional method also increases students' motivation, the effectiveness of AR media is much higher in motivating students. This finding supports previous research, such as that by (Şimşek et al., 2024), which stated that AR media provides a more immersive learning experience and captures students' attention more effectively.

The hypothesis testing results using the Independent Sample T-Test revealed that the significance value (2-tailed) was 0.001, which is less than 0.05. Therefore, the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted, indicating a significant difference between the learning motivation of students in the control and experimental groups. These results align with the study by Utama et al. (2024), which found that AR-based learning significantly increases students' motivation compared to traditional methods. This is because AR allows students to visualize abstract concepts in a more concrete and interactive manner.

The effectiveness of AR media is further supported by the N-gain test results. In the experimental group, the average N-gain percentage reached 77.59%, which is categorized as effective, while the control group only reached 56.56%, categorized as moderately effective. The effectiveness ratio calculation of 1.37 (>1) further strengthens the conclusion that AR-based Android media is more effective than conventional learning methods. This result supports the research by (Meilindawati et al., 2023), which demonstrated that AR-based learning enhances student engagement by providing a more engaging learning experience.

Further analysis of motivational indicators revealed that the experimental group recorded excellent results on the Attention indicator, with a score of 91%, and the Satisfaction indicator, with a score of 87%. In the control group, although the results also showed improvement, the Attention indicator only reached 85%, and Satisfaction was at 78%. These findings indicate that AR media can better capture students' attention and provide a higher level of satisfaction during the learning process. This study supports the argument that educational technologies like AR can enhance affective components in learning, such as motivation and satisfaction.

Overall, this study contributes significantly to the literature on education, particularly in the integration of technology in learning. The results of this research show that AR-based Android media not only improves students' learning motivation but also creates a more interactive, enjoyable, and up-to-date learning atmosphere. For further development, it is recommended that similar research be conducted in other subjects and on a larger scale to test the sustainability of AR media effectiveness in various learning contexts.

Conclusion

Based on the research conducted, it can be concluded that the use of Android-based augmented reality (AR) media is effective in enhancing students' learning motivation in science lessons. This is evidenced by the increase in the average learning motivation scores in the experimental group, the hypothesis test results indicating a significant difference between the control and experimental groups, and the effectiveness test results showing that Android-based AR learning media falls under the effective category. Furthermore, an analysis of learning motivation indicators reveals that the use of AR media significantly improves students' attention and satisfaction, providing a more engaging and motivating learning experience. Therefore, the use of AR-based technology can be an innovative alternative in education to create a more interactive, enjoyable, and student-centered learning environment. The limitations of this study include its scope, which is restricted to science lessons, and the relatively small scale of the research. Therefore, further studies are recommended to expand the application of AR media to other subjects and to test its effectiveness on a larger population. It is

hoped that the results of this study can contribute positively to the field of education, particularly in leveraging technology to enhance students' learning motivation and the overall quality of education.

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