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THE USE OF AUGMENTED REALITY IN SCIENCE LEARNING TO IMPROVE MOTIVATION AND UNDERSTANDING OF SCIENCE CONCEPTS AMONG ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

The objective of this research is to evaluate the effectiveness of Augmented Reality (AR) technology on students' learning motivation as well as understanding of science concepts in elementary school science subjects. The approach used in this research is mixed methods, which is a combination of quantitative and qualitative methods. Quantitative data for this study was collected through pretest and postest tests that afterward were processed descriptive statistical, normality test, Paired Sample t-Test and Pearson correlation analysis. While the qualitative data was collected through interviews and observations and analyzed through thematic analysis. The research findings show that the use of AR technology together with interactive lessons improves learning outcomes as indicated by the students' posttest scores being significantly higher than their pretest scores ($p < 0.05$). In addition, the results of the regression analysis showed a strong, positive and significant relationship between the use of AR technology and students' learning motivation ($r = 0.78$, $p < 0.05$). This study has some implications for teaching practice which suggests that by maximizing the use of AR, teachers can enhance students' motivation and participation in class and also help students to better understand abstracted complex concepts in science subjects. Therefore, broad socialization on the concept of AR integration into the curriculum through teacher training and AR model media development relevant to the learning process need to be carried out.

Keywords: *Augmented Reality, Learning Motivation; Science Concepts; Mixed Method; Educational Technology.*

ABSTRAK

Tujuan penelitian ini adalah untuk mengevaluasi efektivitas teknologi Augmented Reality (AR) terhadap motivasi belajar siswa serta pemahaman konsep sains pada mata pelajaran sains sekolah dasar. Pendekatan yang digunakan dalam penelitian ini adalah metode campuran, yaitu gabungan metode kuantitatif dan kualitatif. Data kuantitatif untuk penelitian ini dikumpulkan melalui uji pretest dan posttest yang selanjutnya diolah dengan statistik deskriptif, uji normalitas, Paired Sample t-Test dan analisis korelasi Pearson. Sedangkan data kualitatif dikumpulkan melalui wawancara dan observasi serta dianalisis melalui analisis tematik. Hasil penelitian menunjukkan bahwa penggunaan teknologi AR bersama dengan pembelajaran interaktif meningkatkan hasil belajar yang ditunjukkan dengan nilai posttest siswa yang secara signifikan lebih tinggi daripada nilai pretest mereka ($p < 0,05$). Selain itu, hasil analisis regresi menunjukkan adanya hubungan yang kuat, positif dan signifikan antara penggunaan teknologi AR dan motivasi belajar siswa ($r = 0,78$, $p < 0,05$). Penelitian ini memiliki beberapa implikasi untuk praktik mengajar yang menunjukkan bahwa dengan memaksimalkan penggunaan AR, guru dapat meningkatkan motivasi dan partisipasi siswa di kelas dan juga membantu siswa untuk lebih memahami konsep-konsep kompleks yang abstrak dalam mata pelajaran sains. Oleh karena itu, sosialisasi yang luas tentang konsep integrasi AR ke dalam kurikulum melalui

pelatihan guru dan pengembangan media model AR relevan dengan proses pembelajaran perlu dilakukan.

Kata Kunci: *Augmented Reality, Motivasi Belajar; Konsep Sains; Metode Campuran; Teknologi Pendidikan.*

INTRODUCTION

The teaching of science in elementary schools formulates a very crucial starting understanding of what candidates will be taught later. However, numerous scientific inquiries reveal that the majority of pupils tend to have problems with understanding abstract concepts in science, such as the solar system, force and motion, state changes of matter, and the water and blood circulation cycle (Sukmawati, 2023) . This problem is often caused by a teaching methodology which is conventional in its essence, that is where the teacher spends most of her time introducing subject matter by reading from a textbook without adequate description. As a result, students are likely to have difficulty relating the theories learned in class with the real-life situations which, in the end, results in their understanding of the concepts not to mention the motivation to learn the subject (Falloon, 2019).

In this digital era, the growth of educational technology has brought innovations to support experiential learning, one of which is Augmented Reality (AR). This technology allows the interaction of the real world and the virtual world, enabling students to visualize abstract concepts in a more realistic and appealing way (Dargan et al., 2023). By using AR, science concepts which are often abstract can now be visualized in a straightforward manner so that students comprehend the concepts textually as well as interactively through visual images. For instance, when studying the solar system, students can incorporate AR to view a 3D model of the planets rotating on their axes as they orbit the sun. Or, during the teaching of the water cycle, students can view the processes of evaporation, condensation, and precipitation occurring in real time through a digital simulation.

Apart from improving concept understanding, AR technology can also help encourage students to study. As noted by various studies, teaching that incorporates various forms of technological support can help create more interesting and enjoyable learning experiences, which in return enhances student participation in the learning process (Hariyono, 2023). However, even though the prospects of AR in education have been discussed widely, real implementations in Primary School Science teaching and learning are still very scarce. This research is therefore intended to assess how the implementation of Augmented Reality can enhance the motivation and understanding of science concepts at the elementary school level and how effective it is against the conventional instructional techniques that are widely used in the primary school level.

Augmented Reality (AR) is a technology that enhances the real world with virtual elements in real time, thus making the learning experience more enjoyable and interactive (Arena et al., 2022). In an educational context, AR has great potential for enhancing learning outcomes by providing a more realistic visualization of abstract concepts (Utama et al., 2024). AR allows students to not only read about a theory or look at images in a book, but also directly interact with a virtual object that resembles a real-life phenomenon. The application of this AR technology adheres to the constructivist theory of learning where there is active student participation in the learning process to assist the learner in developing an understanding through exploration and interactions with the surrounding environment (Subkhi Mahmasani, 2020).

In addition, in educational psychology, motivation theory suggests that students are more motivated to learn when they are engaged and feel that they have some control over their learning processes (Alfiyana et al., 2018). Technology-based learning such as AR can create a more engaging, enjoyable, and motivating learning experience for students to actively explore

the material being studied (Wang, 2020). This is another study that requires the use of interactive media tools to enhance student engagement in the learning process, which leads to deeper understanding and interest on the part of students (Royani & Muafia, n.d.).

In the context of learning Science in Primary schools, students must have adequate understanding of science concepts to help them relate theories with real life phenomena around them. The age rangemost learners from Primary school fall into, according to Piaget (1970), is between six to twelve years old. In this period children learn best with pictures and hands on experience rather than through reading or verbal narrations (Rohani, 2020). Therefore, AR can be an effective supporting tool in bridging the gap between theory and practice in teaching science in primary school.

Even Though several studies have verified that AR has significant advantages in the field of education, there still gaps concerning the application of the technology in teaching science at the primary school level. Previous studies focus more on the application of AR at the secondary school or university level, case studies involve more sophisticated subjects like Physics and Biology in high school and university. In addition, many studies about AR in teaching Science subjects only examine its effects on the students' conceptual understanding without considering how this technology may also simultaneously enhance students' motivation to learn (Djuanda, 2015).

In addition, even though AR technology has begun to be integrated into the education sector, its implementation in the field, especially at the elementary school level, is still very much limited. Numerous schools lack the basic tools necessary to conduct AR lessons, and most instructors are still unfamiliar with this novel technology (Aziz & Zakir, 2022). Therefore, further research is still required to examine how AR can be effectively incorporated into the teaching of science subjects at the primary school level, taking into account the teacher's readiness, infrastructure, and the student's motivation and learning of science in a more holistic manner.

Based on that gap, this research aims to fill the research void by exploring how the use of Augmented Reality can simultaneously enhance motivation and understanding of science concepts among elementary school students in science learning. This research will also examine the effectiveness of AR-based learning compared to conventional methods, as well as the challenges faced in its implementation in elementary school environments. Thus, the results of this research are expected to make a significant contribution to the development of innovative technology-based learning methods in primary education, particularly in science learning in the digital era

METHOD

This study employed a Mixed Methods approach using a Concurrent Embedded Design, prioritizing quantitative data collection and analysis while simultaneously gathering qualitative data to provide supportive context and deeper insights (Almeida, 2018; Azhari et al., 2023). The primary quantitative method was a pre-experimental one-group pretest-posttest design, implemented to measure the change in elementary students' science concept comprehension after an Augmented Reality (AR) based learning intervention (Afiyah & Wahyuningsih, 2023). Concurrently, qualitative methods, including interviews and observations, were utilized to explore student engagement, as well as student and teacher perspectives on the use and effectiveness of AR in science instruction, thereby enriching the quantitative findings.

Participants were elementary school students selected through purposive sampling based on criteria such as prior basic technology use and sufficient preliminary understanding of the science concepts being taught, ensuring data relevance (Lenaini, 2021). Data collection involved multiple instruments: pre- and post-intervention science literacy tests (multiple-choice

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and essay) assessed conceptual understanding and critical thinking; a Likert-scale questionnaire measured student motivation and perceptions towards AR-based learning; semi-structured interviews captured the experiences and challenges faced by students and teachers regarding AR implementation; and classroom observations documented student interactions, engagement levels, and comprehension during the AR-enhanced lessons.

Data analysis followed a parallel approach, treating quantitative and qualitative data separately before integration. Quantitative data underwent descriptive analysis, normality testing (Shapiro-Wilk), significance testing between pretest and posttest scores (using Paired Sample t-Test or Wilcoxon Signed-Rank test), and correlation analysis (Spearman) between AR use and motivation levels (Latri et al., 2020). Qualitative data from interviews and observations were analyzed thematically through transcription, coding key concepts (e.g., AR effectiveness, motivation, challenges), and interpretation. Finally, the findings from both quantitative and qualitative analyses were integrated by comparing and merging the results to form a comprehensive conclusion, examining how the qualitative insights confirmed, contradicted, or elaborated upon the quantitative outcomes (Hendrayadi et al., 2023; Umar & Miftachul, 2019).

RESULT AND DISCUSSION

To evaluate the effectiveness of Augmented Reality (AR) on students understanding of science concepts in elementary school, this study applied different techniques of AR analysis. The data collected was in the form of pretest and postest and included 35 students who had already gone through AR based lessons. The analysis comprised several stages with descriptive test, normality test, difference test (Paired Sample t-Test), and correlation test to examine the relationship between students' learning motivation and their understanding of the concepts after AR intervention.

The descriptive analysis was made to the data of pretest and posttest from 35 elementary school students. The purpose of this uji deskriptif is to analyze the distribution of participants' data, the mean value, the standard deviation, and other relevant characteristics before and after the treatment. The following is the result of pretest and postest descriptive data analysis.

Table 1. Descriptive Statistics Table

Descriptive Statistics	Pretest	Posttest
Number of Students (N)	35	35
Minimum Value	50	75
Minimum Value	65	90
Mean	57,8	82,5
Median	58	83
Modus	59	85
Standard Deviation	4,92	5,18
Varians	24,2	26,8
Range	15	15
Skewness	-0,21	-0,35
Kurtosis	-0,43	-0,52

Descriptive analysis of pretests and posttests of 35 students suggests there was a significant improvement in understanding the concepts after the use of Augmented Reality (AR)

in teaching Science. The mean score increased from 57.8 in the pretest to 82.5 in the posttest with a wider range of scores (50–65 to 75–90). The relatively stable standard deviation (4.92 to 5.18) indicated a common increase among the students. The data distribution is also more left skewed (skewness pretest -0.21 and posttest -0.35), meaning that most students scored high after the treatment.

In order to ensure that the data obtained in this research has met the necessary statistical assumptions, normality test was conducted on pretest and posttest results using Shapiro-Wilk method. If the data is normally distributed, a Paired Sample t-Test will be conducted to determine the difference in significance between the pretest and posttest. However, in the case of non-normal distribution of data, Wilcoxon Signed-Rank Test was used instead. The following contains the results of the statistical tests performed:

Table 2. Statistical Test

Statistical Test	Pretest	Posttest	Interpretation
Normality Test Shapiro-Wilk (p-value)	0,12	0,08	$p > 0,05 \rightarrow$ Data is normally distributed
Paired Sample t-Test (p-value)	0,0001	-	$p < 0,05 \rightarrow$ There is a significant difference between the pretest and posttest.

Normality tests using Kolmogorov-Smirnov and Shapiro-Wilk revealed that the pretest and post-test data had a p value of > 0.05 so normal distribution can be assumed. Because the data is normally distributed, a Paired Sample t-Test was conducted, which resulted in a p-value of 0.0001, which is less than 0.05 implying there is a significant difference between pre-test and post-test scores. Wilcoxon Signed-Rank test was not necessary since the data is normally distributed. These findings indicate that Augmented Reality (AR) use in science subjects significantly boosts students' understanding.

In order to determine the relation between the use of Augmented Reality (AR) in the learning process and students' motivation toward learning, a Spearman correlation test was conducted. This test was selected because students' motivational data was in ordinal level and did not completely fulfill the normality assumption. The purpose of this correlation test is to determine the strength/degree of the relationship of two variables, whether the use of AR positively impacts students' motivation towards learning.

Table 3. Spearman Correlation Test

Statistical Test	Correlation Value (r)	p-value
Spearman Correlation	0,72	0,0005

Based on the analysis results, a Spearman correlation value of r = 0.72 with a p-value of 0.0005 was obtained. This value indicates that there is a strong and significant relationship between the use of AR in learning and students' learning motivation. In other words, the higher the intensity and effectiveness of using AR in the learning process, the higher the level of student learning motivation. This result is consistent with previous research which states that interactive technology-based learning, such as AR, can enhance student engagement and enthusiasm in learning. Therefore, the application of AR in science learning at elementary schools is recommended as an innovative strategy to effectively enhance students' learning motivation.

Research involving the application of Augmented Reality (AR) in the context of teaching Science subjects is a relatively new topic within educational technology. Different studies have shown mixed outcomes concerning the effectiveness of these technologies in improving students' motivation and understanding of science concepts. While some research supports the use of AR technologies as innovative tools to enhance students' learning experiences, other studies have focused on the barriers and difficulties that are encountered in using such technology particularly in primary schools with poor infrastructural and human resources readiness. It is therefore necessary to look at the benefits and challenges of diverse previous studies in order to accurately assess the impact of AR in teaching and learning processes.

One of the main advantages of using AR in science learning is the ability to help students visualize abstract concepts that are difficult to comprehend through textbooks or traditional lectures. Research by (Resti et al., 2024) showed that AR provides students realistic experiences with virtual objects representing scientific phenomena like the solar system, force and motion, and water cycle. Their research results showed that there was a significant increase in students' understanding of concepts after their use of AR technology because students can see how a concept works in 3D animated interactive visualizations. Moreover, research by (Haryani et al., 2024), found that learning with the use of AR technology increases students' motivation to learn since it is more interesting and enjoyable compared to traditional methods. The presence of interactivity in AR makes students feel that they are part of the learning processes and this can positively increase their interest in learning science. Other studies also pointed out that AR enables learners to study scientific phenomena independently, which stimulates greater interest in the subject.

However, although many studies show the benefits of AR in science learning, there are several other studies that highlight the challenges and limitations in the implementation of this technology in elementary school environments. One of the main challenges is the readiness of school infrastructure to support the use of AR, such as the availability of compatible devices, stable internet access, and teachers' readiness to operate AR-based applications. Research conducted by (Zaky et al., 2024) revealed that not all schools have devices that support the use of AR, especially in areas with limited resources. Teachers often face difficulties in integrating this technology into learning due to a lack of training and guidance in using AR. Furthermore, research by (Muharram & Susanti, 2024) shows that although AR can enhance students' conceptual understanding, not all students feel comfortable with this technology. Some students have difficulty adapting to AR applications due to a lack of experience in using digital devices. In some cases, students become too focused on the technological aspects rather than understanding the scientific concepts being conveyed.

In addition to the technical challenges, there are also some researches that focus on the pedagogical aspect of AR use. A study from (Aini et al., n.d.) suggests that while AR can enhance students' engagement in learning, its effectiveness is largely based on how teachers devise the appropriate strategies to facilitate learning. If the teachers rely on AR technology without having teaching methods, the technology benefits will not be optimal. AR must be combined with active learning methods such as project-based or inquiry-based with technology so that students do not only see the interesting visualizations, but also understand the concepts being taught. Furthermore, some studies also state that excessive use of AR for an extended period of time can lead to cognitive fatigue of the students, particularly for those who are not used to this technology.

Based on various previous research findings, it can be concluded that the use of AR in science learning has great potential in enhancing students' conceptual understanding and learning motivation, but its implementation also faces various challenges that must be

addressed. The results of this study are in line with various studies that show that AR can be an effective tool in helping students understand abstract concepts through interactive visualization. However, the challenges identified in previous research, such as infrastructure readiness, teachers' skills in using AR, and students' adaptation to new technology, must also be considered in the implementation of AR in elementary schools. Therefore, this research emphasizes the importance of providing training for teachers, improving access to infrastructure that supports AR, and developing learning strategies that optimize the use of this technology. Thus, AR can truly provide maximum benefits in enhancing the quality of science education at the elementary school level.

CONCLUSION

From the research, it can be concluded that the application of Augmented Reality (AR) technology in learning Natural Science at elementary school has a positive effect in increasing students' concept comprehension and learning motivation. The statistical test results displayed a significant difference between pretest and postest results, which indicates that AR based learning is effective in enabling students to comprehend abstract scientific concepts. In addition, the results of the correlation test between the use of AR and the students learning motivation proved significant strong relationship which means the more frequent and effective AR is used in the instruction, the higher the students motivation will be. This shows that AR technology not only serves as a visual aid but also enhances student engagement in the learning process. However, this research also identifies several challenges in the implementation of AR, such as the limitations of school infrastructure, teachers' readiness to operate the technology, and students' adaptation to digital-based learning. Therefore, in order for the use of AR to be more optimal, support is needed in the form of teacher training, provision of adequate devices, and the development of appropriate learning strategies. With the proper use of AR, this technology can become a promising innovation in enhancing the effectiveness of science learning in elementary schools.

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