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Augmented Reality (AR) Learning: Improving Students Memory in Science Learning at the Elementary School Level

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ABSTRACT

Education as one of the fields that is also affected, adapts to the rapid advancement of technology, ranging from curriculum changes to the use of various learning resources and technology-based learning media. One of the innovations that has emerged is the use of Augmented Reality (AR) as a learning medium. This study aims to evaluate the effectiveness of the use of AR in improving students' memory of learning materials. The method used in this study is the Kurl Lewin model action learning research method with a qualitative experimental approach that positions teachers to play an active role in implementing learning problem-solving interventions that occur in the learning of grade V students of SD Negeri Panjang Wetan 03 Pekalongan. The findings of this study show that AR media can facilitate students in understanding and remembering science material. In addition, AR is also effective in describing abstract concepts that are difficult to practice or observe directly. The implications of this research can be the basis for educators, policy makers, and learning media developers to implement AR technology more widely in the learning process, in order to improve the quality of education and enrich the learning experience of students.

Informasi Artikel

Kata Kunci:
Augmented Reality (AR); Penguatan Daya Ingat; Pembelajaran IPA; Sekolah Dasar

ABSTRAK

Pendidikan sebagai salah satu bidang yang turut terdampak, beradaptasi dengan pesatnya kemajuan teknologi, mulai dari perubahan kurikulum hingga pemanfaatan berbagai sumber belajar dan media pembelajaran berbasis teknologi. Salah satu inovasi yang muncul adalah penggunaan *Augmented Reality* (AR) sebagai media pembelajaran. Penelitian ini bertujuan untuk mengevaluasi efektivitas penggunaan AR dalam meningkatkan daya ingat peserta didik terhadap materi pembelajaran. Metode yang digunakan dalam penelitian ini adalah metode action learning research model Kurl Lewin berpendekatan kualitatif eksperimental yang memposisikan guru berperan aktif dalam mengimplementasikan pemberian intervensi pemecahan masalah pembelajaran yang terjadi dalam pembelajaran siswa kelas V SD Negeri Panjang Wetan 03 Pekalongan. Temuan penelitian ini menunjukkan bahwa media AR dapat memfasilitasi peserta didik dalam memahami dan mengingat materi IPA. Selain itu, AR juga efektif dalam menggambarkan konsep-konsep abstrak yang sulit dipraktikkan atau diamati secara langsung. Implikasi penelitian ini dapat menjadi

dasar bagi pendidik, pembuat kebijakan, serta pengembang media pembelajaran untuk mengimplementasikan teknologi AR secara lebih luas dalam proses pembelajaran, guna meningkatkan kualitas pendidikan dan memperkaya pengalaman belajar siswa.

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INTRODUCTION

The learning process is a dynamic interaction between educators and students that aims to achieve certain competencies (C.-M. Chen & Tsai, 2012). Teachers have an important role in achieving learning goals, they not only convey information but also have the ability to direct the growth of students' attitudes, physical skills, and psychological aspects. This role is critical to the teacher's success in achieving learning goals (Akçayır et al., 2016; Haneda et al., 2024). In this case, teachers must ensure that the learning environment becomes interesting and enjoyable so that students do not get bored or bored. Therefore, to ensure that lessons are well understood and accepted by students, teachers must have the ability to create and implement innovative and engaging learning media.

At the basic education level, science learning plays a role in developing students' critical attitudes, curiosity, and scientific abilities (Huang et al., 2016). Science learning requires a deep understanding of concepts, experimental skills, and the application of scientific attitudes. To achieve these goals, teachers must have special skills in creating an interesting and not boring learning process (Al-Hail et al., 2023; Sikström et al., 2024). This is especially important given the field research that shows that many students find science material so difficult to understand (Lee et al., 2023; Ullah et al., 2022).

Along with the rapid development of science and technology, teachers are faced with the challenge of innovating in learning in a sustainable manner, in line with the demands of globalization. One of the main demands is the use of more modern and technology-based learning media, which can support students' learning activities in the classroom and contribute to the achievement of optimal learning outcomes (Mydin et al., 2024). In this case, learning technology is very important as a tool that teachers use to deliver lessons and help students understand them better (Harjana et al., 2023).

Learning media can be defined as anything that can be used to convey a learning message or material with the aim of attracting attention, increasing interest, and encouraging students' cognitive and emotional processes. Gunawan et al. (2023) stated that the use of this learning media is intended to ensure that learning objectives are achieved. Learning media does many things, one of which is to make the message conveyed clearer, reduce the dependence on verbal explanations, and make it easier for students to understand what is being conveyed. Thus, the media functions to directly describe the message or information that is to be conveyed, so that students do not need to have difficulty in imagining or imagining the material they are learning (X. Wang et al., 2023). One type of media that can be used by teachers is AR-based learning media.

An innovative solution to improve the learning experience of Natural Sciences in elementary schools is the use of AR in learning. AR combines multisensory learning experiences that use more than one sense, such as touch and sight, by combining visual and interactive elements. Information that is perceived directly through sensory experience is easier to remember than information that is only listened to auditorily, this method has been proven to be effective in improving students' memory and understanding of learning materials (Pujiastuti & Haryadi, 2024).

Augmented Reality (AR) is a technology that allows interaction between the physical world and the virtual components added to it (Rusli et al., 2023). The technology combines two-dimensional and three-dimensional computer-generated objects with the user's real-time environment. Objects displayed through AR technology can provide a new experience to users, allowing for direct interaction with the existing physical environment (Villena-Taranilla et al., 2022).

AR learning is widely applied in interactive multimedia for learning, such as in learning presentations, where this technology supports teachers in visualizing objects more clearly and interestingly (C.-Y. Lin et al., 2016). However, AR technology is not intended to replace the role of teachers as a whole, but rather serves as a tool that enriches the learning process, with teachers still playing the role of facilitators (Liono et al., 2021).

AR-based learning media has several advantages, including: (1) increasing interactivity (Bakkiyaraj et al., 2021), (2) effective in its use (Gargrish et al., 2020), (3) can be widely applied to various media (Mahr et al., 2023), (4) allows for simple object modeling (Kao & Ruan, 2022), (5) Manufacturing that does not require high costs (X. Lin et al., 2024), and (6) easy to operate (Chang & Hwang, 2018). However, AR technology also has several drawbacks, such as: (1) sensitivity to changes in perspective, (2) limited development of AR applications, and (3) large device memory requirements (Ibáñez & Delgado-Kloos, 2018).

The use of AR media in the visualization of learning materials has been proven to have a significant positive impact. For example, in a study conducted by Yang et al. (2023) on the use of AR in explaining circulatory materials, it was found that the use of AR was more able to attract students' interest compared to conventional learning methods. Other research conducted by Fakhrudin et al. also showed that the application of AR in science learning can improve student learning outcomes (Salmi et al., 2012). As stated by Annetta

et al. (2024), the use of AR in science learning, especially on the concept of the nervous system, has proven to be very effective with a success rate of 76%. In addition, Sahin & Yilmaz (2020) summarized the results of the study which showed that the use of AR media can improve students' understanding of the material, learning effectiveness, and learning motivation, which in turn contributes to the improvement of overall learning outcomes.

Referring to the literature of previous research, the novelty of the research to be carried out can be focused on aspects that have not been explored in depth in previous research. This research focuses on the application of AR in the context of science learning by emphasizing the use of three-dimensional (3D) visualization for science phenomena that are difficult to observe directly. This approach aims to bridge science concepts with real-world contexts and students' practical experiences, through virtual experiments or simulations of real-life situations that are relevant to students' daily lives.

The novelty in this study lies in the in-depth exploration of the use of AR in science learning, which includes variations in the application of AR in various aspects of learning, analysis of its influence on the development of students' critical and collaborative thinking skills, and comparison of its effectiveness with other learning technologies, in order to provide a new perspective on the advantages of AR in improving the quality of education. This view prompted this study to investigate how the use of AR media can improve students' memory, especially in the context of Natural Sciences (IPA) learning in elementary schools.

METHOD

This study uses a descriptive qualitative approach with a descriptive action learning research method of the Kurl Lewin model experiment, which aims to analyze and explain learning events that place teachers as intervention providers to solve learning problems (Cortes et al., 2025). This method is considered appropriate to explore a holistic and natural understanding of an issue, so as to provide a more comprehensive picture of the learning context in the classroom (L. Chen, 2022; Yilmaz, 2013).

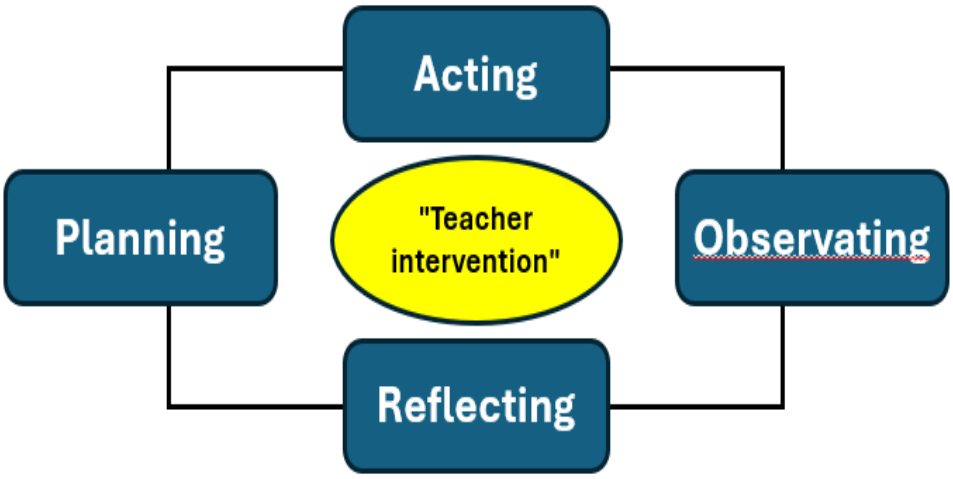

Figure 1. Action Learning Research Model Developed by Kurl Lewin

The main basis for choosing the method is that it is assumed to be able to produce accurate data in the form of narratives that describe and explain learning phenomena in detail and contextually, so as to allow the accurate collection of research data (J. C. Wang & Wang, 2023). The Kurl Lewin model action learning research to analyze the application of augmented reality in testing its reliability on students' memory faculties regarding science learning is concentrated in class V of SD Negeri Panjang Wetan 03 Pekalongan which serves as a pilot project for the application of AR in learning.

Data was collected through the results of learning interventions by applying AR with the PAOR (Planning, Acting, Observing, and Reflecting) cycle flow which was then analyzed to obtain relevant information. The data analysis process is carried out by classifying and sorting information obtained from the results of empirical observations in the classroom and documentation studies so that it can be compiled into a systematic explanation and able to provide answers to research questions (Hancock et al., 2021).

RESULT AND DISCUSSIONS

A. Result

Improving students' memory in science subjects by utilizing AR media as part of learning in schools that are the location of this research pilot project. The data presented showed that of the 25 students tested, as many as 11 students (44%) managed to identify and remember the information contained in the subject matter well. In contrast, the retention aspect of information, which measures the extent to which students are able to remember and retain information over a period of time, has the lowest frequency, where only 5 students (20%) are able to retain the information well.

In addition, the aspect of mapping the information remembered, which indicates the students' ability to organize and relate the information they obtain, can be done by 9 students (36%). These findings provide an initial overview of how AR media can affect students' memory ability and understanding of science concepts at the primary school level.

Table 1. Memory Ability of Science Concepts Results of Using Augmented Reality (AR)

Memory Aspects	Frequencies (n=25)	Frequencies (%)
Memory recognizes material information.	11	44
The impression is that the information is remembered.	5	20
Information mapping memory.	9	36

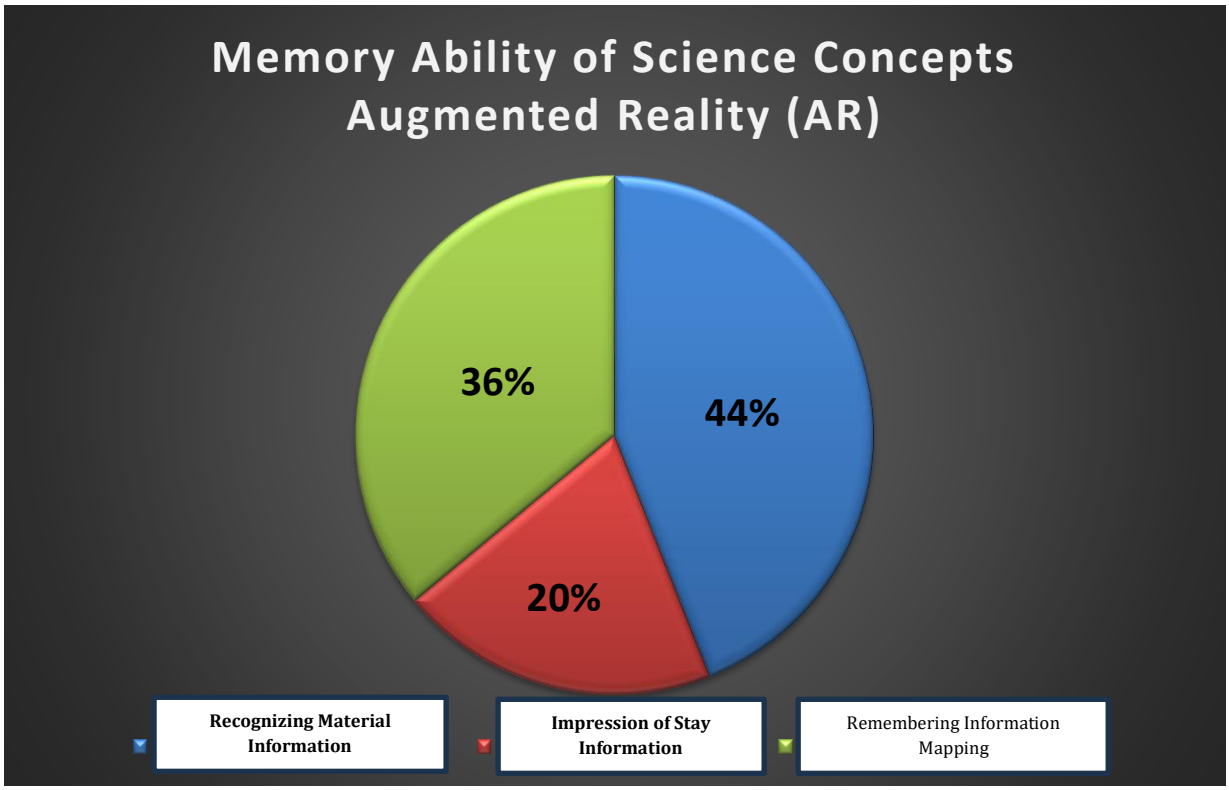

Figure 2. Percentage of Students' Memory Ability of Science Concept Materials

This study makes an important contribution to the understanding of the impact of AR utilization in the context of science learning in elementary schools. The findings of this study show that the use of AR can improve students' ability to recognize and remember information contained in learning materials. This improvement shows that AR not only functions as a medium that attracts students' attention, but also as an effective tool in supporting students' cognitive processes, such as concept comprehension and information retention.

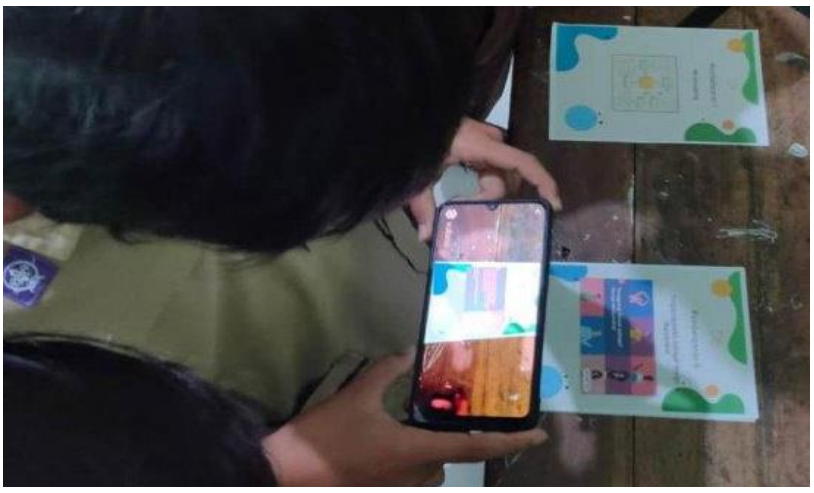

Figure 3. Science Learning Activities based on the Utilization of Augmented Reality

The application of AR offers a more interactive and visual approach to learning, which can help students understand science concepts that are often abstract and complex (Park & Stangl, 2020). By providing a more real and contextual experience, AR allows students to manipulate virtual objects in three-dimensional space, thus facilitating a deeper understanding of the material being taught (C.-Y. Lin & Chang, 2015).

Furthermore, the use of innovative learning technologies such as AR in the classroom can improve conventional learning methods, which are usually limited to static verbal and visual techniques (C.-H. Chen et al., 2016). By using ICT in science learning, students can gain 21st century skills such as digital literacy, problem-solving, creativity, and collaboration (Wei et al., 2015). Therefore, the use of AR not only helps students achieve the competencies listed in the curriculum but also educates them to face the increasingly complex demands of a future where critical thinking skills and technological skills are in high demand.

In addition, these findings also suggest that the integration of AR in science learning can serve as a catalyst for changes in pedagogical practices in primary schools, encouraging the development of more flexible, adaptive, and student-oriented teaching methods. Therefore, further research on the implementation and evaluation of AR in various educational contexts will be very valuable to explore the potential of this technology in improving the overall quality of education.

B. Discussions

The results of the study show that the use of learning media that is able to visualize concepts in Natural Sciences (IPA) learning has a significant impact on students' learning outcomes, motivation, and interest, which ultimately affects students' memory ability of the material studied. Science learning at the elementary school level requires Augmented Reality (AR) media that can support the critical and creative thinking of Generation Z students, so the right and ideal learning strategy is needed (Chiang et al., 2014). Along with the demands of 21st century learning, the approach to learning science by utilizing digital media is crucial to create a deep and interesting understanding for students, while avoiding boredom in the learning process (Arici et al., 2019; Sato & Kitamura, 2023; Sommerauer & Müller, 2014).

AR technology enables innovation in the use of digital learning media for science in elementary schools. AR allows students to see three-dimensional (3D) objects, see abstract concepts, and participate in educational games, which makes learning more engaging and interactive (Haider et al., 2024). It improves students' ability to solve problems and think critically. Augmented reality (AR) technology has a lot of potential in the world of education, especially in science learning, as AR can offer more engaging educational materials through the integration of virtual elements with the real world, allowing students to learn through powerful and hands-on visual experiences, which significantly improves the learning process (Yamin et al., 2024).

AR technology can be used in a variety of ways, which helps students understand ideas better (Upadhyay et al., 2024). First, AR can be used to improve visual learning by facilitating the visualization of abstract concepts (Latif et al., 2023). As an illustration, AR technology can be used in Natural Sciences learning to display representations of human body organs on top of textbooks, giving students the opportunity to explore and understand more about the structure of the human body (X.-F. Lin et al., 2024). AR leraning can also enable the simulation of virtual experiments, allowing students to conduct scientific experiments in a safe environment (Ferdiman et al., 2023; Sahu et al., 2024).

In addition, AR has also proven to be effective in describing abstract concepts and arranging objects visually, thus making it a learning medium that is more in line with educational goals (Putra et al., 2023; Wu et al., 2013). In terms of effectiveness, many students reported that the use of Android-based AR media in science lessons can help them in understanding and memorizing scientific material, making it easier for them to understand science lessons more thoroughly. This technology also gives students the freedom to learn on their own terms, which contributes to their increased creativity and imagination. Another benefit of using AR is its ability to improve student concentration, which in turn supports better learning success (Li et al., 2023; Shim, 2023).

The use of AR technology in the development of learning media offers a significant experience for both teachers and students. AR technology serves as a link between theoretical and practical learning by combining real and virtual elements, creating a unique and interactive learning experience (Giorgio et al., 2023; Oranç & Küntay, 2019). Based on a systematic review of research and applications of AR in education, the use of this technology has proven to be effective in achieving various educational goals, such as improving learning performance, learning motivation, student engagement, and positive attitudes towards subject matter (Amir et al., 2020; Deshpande & Kim, 2018).

The explanation can be understood that visual media, including visual symbols, has a significant impact on the learning process. This is in line with Edgar Dale's theory which states that visual symbols can be used as one of the effective learning media options (Yen et al., 2013). The selection of learning media is a crucial step to create quality learning (Tirado-Morueta et al., 2020).

Every teacher needs to have a deep understanding and skills in choosing the right media, based on careful consideration. In choosing learning media, teachers must consider the quality of the media itself, as well as the suitability of the media with the needs and characteristics of users, both students and teachers. The selection of the right media is expected to optimize student learning outcomes and improve the quality of the overall learning process (Nincarean et al., 2013; Suchyadi et al., 2020).

CONCLUSIONS

The use of Augmented Reality (AR) media in learning can improve students' ability to identify and remember information contained in Natural Sciences (IPA) subject matter. However, despite the improvement in the ability to recall information, the results of the study showed that students' ability to retain information over a period of time and organize the information they obtained was still limited. As many as 44% of students managed to remember the material well, but only 20% were able to retain information in the long term, while 36% of students were able to map and organize the information they had learned. These findings suggest that AR media can have a positive impact on students' comprehension and memory, but its effectiveness in retaining information and organizing knowledge still needs to be improved. To improve students' ability to retain information, it is recommended that the use of AR be integrated continuously in the learning process, not just as a single-use activity. Providing opportunities for students to regularly access and use AR media is expected to improve their memory and extend the information retention period. With consistent and structured application, AR media is expected to be more optimal in supporting the improvement of students' memory skills, concept understanding, and skills in organizing information, especially in the context of science learning in elementary schools.

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