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Implementation of Augmented Reality (AR) Animation Media to Enhance Learning Outcomes and Interest in the Excretory System Topic

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Abstract: The excretory system material requires visualization to enhance understanding. To help students grasp the concepts of the excretory system more effectively, the various organs of the excretory system must be illustrated in the learning material. Therefore, learning animations are needed that can display images created with augmented reality media, appearing almost lifelike in 3D form. This study aims to analyze the application of augmented reality animation media in improving learning outcomes and the difference in students' interest before and after learning about the excretory system with augmented reality animations. The method used is a quasi-experiment with a pretest-posttest control group design. The sample consists of 54 students from SMA Negeri 1 Ingin Jaya Aceh Besar, selected using random sampling techniques. Data were collected through multiple-choice tests and a questionnaire on students' interest in the excretory system material. The data were analyzed using a t-test, showing a significant difference in learning outcomes in the experimental class with a p-value < 0.05 (0.022 < 0.05), and a significant difference in students' interest before and after the learning process in the experimental class with a t-test result of p < 0.05 (0.037 < 0.05). It can be concluded that the application of augmented reality media can enhance learning outcomes and affect students' interest in the excretory system material.

Keywords: Augmented reality; Excretory system; Learning interest; Learning outcome

Introduction

The use of this technology can help complete tasks easily. In line with the development and demands of the times, this technology is utilized in almost all aspects of human life. One aspect that is closely tied to the use of technology is education (Sepdyana et al., 2022). The rapid development of science and technology today requires education to actively participate in using technology as an innovation in learning. Indonesia still adheres to mass education or education 2.0, and it is time for Indonesia to make improvements toward education 4.0 based on artificial intelligence (AI) (Budiyono, 2020). One component that needs to be transformed to move towards education 4.0 is by shifting from traditional learning media to modern learning media (Endarto, 2022). Educational Technology helps achieve learning goals in an effective and efficient manner (Agustian & Salsabila, 2021). By using Educational technology in the learning process can improve understanding of the material and interest in learning. Educational technology also helps teachers to be more creative and

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innovative in preparing the learning process (Rahmawati & Kamaludin, 2024).

The excretory system material is a material that requires visualization. In order for students to understand the concept of the excretory system better, the forms of the excretory system organs must be depicted in the material. Therefore, learning animations are needed that can show images made from augmented reality media that look real in 3D. As an alternative solution to this problem, Augmented Reality (AR) media was chosen. Augmented Reality is an innovation where AR technology has the ability to project computer graphics into the real world (Widiasih et al., 2023).

Augmented reality is a popular technology in various fields, especially in education. Its application in chemistry learning is considered appropriate because it can increase learning motivation, learning achievement and effectiveness in the learning process (Khairani & Prodjosantoso, 2023). One application of educational technology is the use of augmented reality-based media (Akçayır & Akçayır, 2017). Augmented Reality (AR) is a visual technology that projects computer-generated information onto the user's view. AR can also integrate virtual environments to appear realistic or display virtual 3D objects, making it possible to interpret AR as the integration of real-time physical objects with virtual objects that appear when applying a device to real-world objects through the aid of a camera (Socrates & Mufit, 2022). The use of technology to provide educational materials can make learning more interesting, motivating, stimulating, and effective for students (Singhal et al., 2012). One of the reasons why students struggle with principles. This topic is the use of traditional education. This can be done causes students to become less interested in those topics hinder their academic success (Whatoni & Sutrisno, 2022).

Augmented Reality (AR) technology is a technology that combines virtual information with the real world. This technology utilizes various technical tools, including Multimedia, 3D Modeling, Real-time Tracking and Registration, Intelligent Interaction, Sensing, and more. Its working principle involves applying virtual information generated by a computer, such as text, to the real environments (Chen et al., 2019). Augmented Reality is defined as technology that combines the real world with the virtual world, is interactive in real-time, and takes the form of three-dimensional animation (Prananta et al., 2024). Traditional knowledge learning generally focuses on the delivery of information and relies on repetitive training as the primary teaching method. When AR is applied in the field of education, this technology uses context as a bridge connecting the classroom with the real world, transforming passive learning into active engagement and abstract concepts into visual ones. The gradual implementation of augmented reality (AR) technology in education supports situational learning methods that are independent and collaborative for students. This "situational shift" has become an important background in learning sciences (Zhao et al., 2020).

Augmented Reality must have three characteristics: combining the real and virtual worlds, real-time interaction with the user, and being registered in 3D space. Augmented Reality allows users to view virtual objects in the real world and aims to enhance reality without fully immersing the user in a synthetic environment (Kesim & Ozarslan, 2012). Augmented Reality is a technology that combines two-dimensional or three-dimensional virtual objects and then projects these virtual objects in real-time (Hutahaean et al., 2022).

Learning media that utilizes Augmented Reality technology can significantly enhance student comprehension by providing real-time visualizations of 3D objects, text, images, videos, and audio. This interactive engagement empowers learners to actively participate, making Augmented Reality a valuable tool that offers immediate feedback, thereby increasing student satisfaction (Mustaqim, 2016).

Animations possess a powerful visual and auditory appeal, capable of stimulating students' imagination and creativity (Supardi et al., 2015). Through the appropriate use of animation, complex or abstract learning materials can be conveyed in a manner that is more easily comprehensible to students. Moreover, animations can present information interactively, enabling students to engage actively in the learning process (Melati et al., 2023). Learning outcomes serve as an evaluation tool that can reveal not only cognitive processes but also affective and psychomotor domains. These outcomes, often represented by numerical scores or grades, signify the results of the learning process and reflect observable and measurable changes in learners' behaviors.

Every parent who sends their child to school aspires for their child to achieve academic excellence. However, attaining this goal is not a simple task. Success in learning is influenced by numerous factors, one of which is the student's interest in learning. Interest is defined as a preference or attachment to something or an activity, without external coercion. Consequently, interest signifies a strong inclination, enthusiasm, or desire towards something (Slameto, 2003).

Indicators of learning interest include: 1) feelings of enjoyment, 2) curiosity to learn, 3) attentiveness during learning, and 4) active involvement in learning activities. Examples of indicators of interest are: 1) focused attention and thoughts on the learning task due to curiosity, 2) feelings of enjoyment during learning, and 3) a willingness and inclination to be actively engaged in

learning and striving for excellence (Friantini & Winata, 2019).

There are seven characteristics of learning interest: interest develops concurrently with physical and mental growth, interest is contingent upon learning activities, the development of interest may be limited, interest is dependent on learning opportunities, interest is influenced by culture, interest is emotionally charged, and interest is egocentric, meaning that when someone enjoys something, a desire to possess it arises. (Marleni, 2016).

Method

The research design employed in this study is a nonequivalent control group design. The first group received an intervention using Augmented Reality media, while the second group followed a conventional learning approach. The design is illustrated in the table below

Table 1. Nonequivalent Control Group

Subject	Pretest	Treatment	Postest
Experimental	O1	X	O2
Control	O3	-	O4

Description:
O1 = Pretest in the experimental group
O2 = Posttest in the experimental group
O3 = Pretest in the control group
O4 = Posttest in the control group
X = Application of Augmented Reality

This research was conducted at SMAN 1 Ingin Jaya. The sample was selected using random sampling. The research sample consisted of two classes: XI IPA 1 as the experimental class and XI IPA 2 as the control class. The initial stage of this research was to administer a pretest to students in both the experimental and control classes to determine their initial abilities. The pretest consisted of 20 multiple-choice questions that had been validated and found to be reliable. The results of the pretest were then tested for homogeneity and normality. Both classes had homogeneous initial abilities and were normally distributed Learning activities in the experimental class were given treatment in the form of augmented reality animation media, while the control class received conventional learning. After the learning process was completed, a posttest was given to students in both classes to determine the final abilities of the students after being given the treatment. The homogeneity and normality of the posttest results were then tested, and both classes had homogeneous final abilities and were normally distributed, as can be seen in the following table 2.

Table 2.Test Result

Class	N-gain	Normality	Homogeneity
Experimental	51.42	0.20	0.729
Control	42.37	0.74	0.729

Normality test is significant at P > 0.05. Homogeneity test is significant at P > 0.05, using the Shapiro-wilk test.

Result and Discussion

Evaluation of students' learning outcomes in the conducted research through pre-test, post-test, and N-gain scores, aiming to determine the improvement in students' learning outcomes between the experimental and control groups.

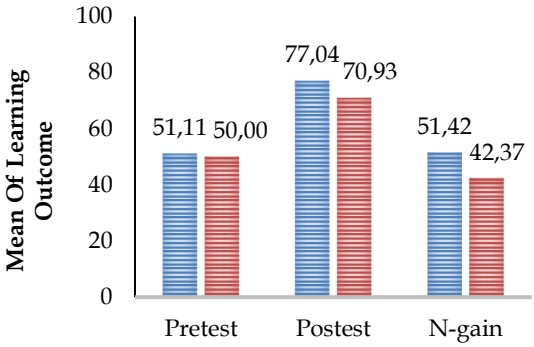

Figure 1. Comparison graph of the average percentage of pre-test, post-test, and N-gain scores of student learning outcomes

Based on Figure 1, the average pre-test scores of students in the experimental and control groups have a nearly similar range, indicating that students in both groups have similar initial abilities. For the post-test scores, both groups showed an improvement. However, the experimental group exhibited a higher increase in scores. The N-gain analysis indicates that the improvement in the experimental group, which used animated media, was quite effective, while the improvement in the control group was categorized as less effective.

The results of the statistical test indicate that the application of augmented reality animation has a significant impact on student learning outcomes (P < 0.05). In the control group that followed the conventional learning model, students experienced confusion in solving problems or in the process of obtaining final results. When students lacked interest or confidence in solving the problems, they tended to be reluctant to try. As a result, the learning outcomes of students who followed conventional learning were generally lower compared to the experimental group. The research results indicated that the experimental group achieved higher learning outcomes compared to

the control group. This is attributed to the implementation of augmented reality animation in the experimental group, which significantly increased students' interest in learning and consequently influenced their learning outcomes. The engaging and user-friendly nature of augmented reality in the experimental group facilitated students in developing the ability to recognize concepts, apply knowledge and skills to create or design solutions, and analyze and utilize mathematical data to solve problems.

The Augmented Reality method also offers an interactive advantage by utilizing markers to display specific three-dimensional (3D) objects when directed towards a smartphone camera (Liono et al., 2021). This aligns with the notion that the strength of this medium in education lies in its interactivity, as Augmented Reality presents 3D objects with engaging interfaces that closely resemble real-world counterparts, thereby enhancing students' reasoning and imagination. Consequently, the use of Augmented Reality in high school education is diverse and deemed suitable (Alfitriani et al., 2021).

Fadhila (2023) research indicated that interactive learning significantly enhanced students' academic achievement. This suggests that interactive learning methods can effectively improve learning outcomes. The implementation of technology, such as Augmented Reality (AR), can facilitate students' comprehension of subject matter and enhance their spatial abilities. Moreover, AR shares similar characteristics and functions with traditional instructional media, as it serves to convey information between the sender and receiver, clarify information, and stimulate motivation and interest in learning (Mustaqim et al., 2018). Juwita (2021) study demonstrated that the use of Augmented Reality (AR) in teaching the musculoskeletal, digestive, and nervous systems significantly improved students' learning outcomes. By visualizing these systems through AR, students were able to develop critical thinking skills, a crucial aspect of science education. AR effectively facilitated the development of scientific inquiry skills, enabling students to observe, predict, and test hypotheses.

Students' learning interest was measured using a validated interest questionnaire. This questionnaire was only administered to the experimental group, while the control group did not receive the interest questionnaire. The results of the post-test interest survey after the implementation of augmented reality animation can be seen in Figure 2 Based on the number of statements and the assigned scores, the maximum possible score for students was 75, and the minimum score was 15. The overall interest level was determined by calculating the average score obtained by the students, which was then tabulated as a percentage and categorized based on a predetermined formula. To assess the increase in interest, the interest questionnaire was administered twice: as a pre-test and a post-test. The learning interest was determined based on the students' responses to the questionnaire given to the experimental group.

At the beginning of the learning process, students' initial interest, after being given a pretest on interest, showed an average interest score from the students' questionnaire responses. For the indicators of enjoyment towards learning, interest, attention, and enthusiasm for learning, the average score was 41.67, which falls under the 'moderately low' criteria. During the learning process, the implementation of augmented reality animation media showed an increase in their interest to 70.88, which falls under the 'high' criteria, indicating a very significant improvement. The low initial interest in learning was due to the lack of enjoyment towards the subject matter and the absence of enthusiasm in following each lesson. Additionally, students did not have the intention to study, as evidenced by the lack of effort to read books related to the subjects or to pay attention to the teacher, which was a result of conventional teaching methods that lacked variety in teaching approaches or models.

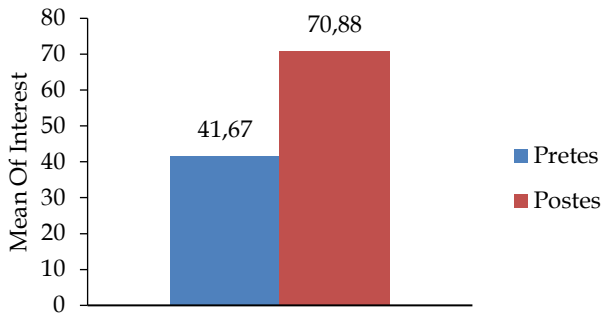

Figure 2. Differences in Students' Learning Interest

Statistical analysis revealed a significant difference between the pre-test and post-test scores for learning interest. The multimedia, interactive, animation-based media developed for this study was effective in delivering engaging learning materials. Initially, students exhibited low levels of interest, but after being exposed to augmented reality animation, their interest increased significantly. This was evident in their high level of enthusiasm during the learning process using augmented reality animation.

One of the internal factors influencing students' learning interest is attention. Curiosity is a driving force behind students' attention. Therefore, this curiosity needs to be stimulated to ensure that students consistently pay attention to the subject matter being taught. Attitude refers to the ability to accept or reject an

object based on an evaluation of that object. A student's attitude, like motivation, can initiate and direct their activities. Aptitude refers to the innate potential or ability that an individual possesses. Each individual has unique aptitudes. Individuals tend to learn more easily when the subject matter aligns with their aptitudes (Marleni, 2016). An interest can be expressed through a statement indicating a student's preference for one thing over another, or it can be manifested through participation in an activity (Sholehah et al., 2018). The first indicator is the feeling of pleasure; students' enjoyment in learning is a crucial factor in the learning process. Students who feel happy will learn comfortably and will not feel stressed (Hulu & Telaumbanua, 2022). The results obtained before and after learning were in the very high category. The second indicator is interest; a person's interest stems from a sense of wonder towards something new, but not everyone is interested in new things. Similarly, creating an engaging classroom atmosphere requires high creativity from teachers to keep up with technological advancements, as engaging learning will enhance students' interest in learning (Rahmawati & Kamaludin, 2024). The third indicator is attention; when students pay close attention during the teacher's explanation, their attention will demonstrate their liking for the taught material. The obtained value was in the high category, indicating that the use of augmented reality animation media had a significant impact on students' attention (Aisyah et al., 2022).

The findings of this study corroborate the previous research conducted by Akhmad Sugiarto, entitled "The Use of Augmented Reality Assemblr Edu Media to Enhance Understanding of the Circulatory System Concept". Teachers in the 21st century, amidst the era of Industry 4.0, must innovate to ensure that learning is effective, enjoyable, and aligned with learning objectives. To facilitate smooth and targeted learning, teachers need to prepare well-designed materials supported by engaging and accessible media. One such readily available medium is the Android smartphone, which is owned by almost everyone. The results of this study demonstrate that the use of three-dimensional (3D) augmented reality media, specifically Assemblr Edu, can significantly enhance students' understanding, as evidenced by the 96.97% improvement, thus motivating them to learn (Surani & Fricticarani, 2023).

Factors influencing learning interest can be broadly categorized into two groups, similar to those affecting learning outcomes: internal factors and external factors. Internal factors are those related to the student themselves, including physical and psychological conditions (Charli et al., 2019). Physical conditions refer to the state of the body, such as the completeness of body parts, normal functioning of organs, and overall physical health. Other internal factors that influence learning interest include psychological conditions related to emotions, motivation, aptitude, intelligence, and basic abilities in a particular subject area (Setiawan et al., 2022). The use of interactive multimedia can overcome problems in learning. revealed that the results of learning models or learning media through interactive media can increase student interest so that learning achievement can increase (Anggraeni et al., 2021).

Teachers can enhance students' interest in learning by creating a conducive and cooperative learning environment, actively involving students in every step of the learning process through positive communication, and connecting classroom learning to real-world applications. The use of Augmented Reality (AR) in teaching landforms demonstrates that AR can effectively capture students' attention, a key indicator of learning interest (Alfitriani et al., 2021). Learning interest is not an innate trait; it is developed over time. It is a strong inclination towards something. Interest does not arise in a vacuum; it is often driven by underlying needs (Friantini & Winata, 2019).

Conclusion

There was a significant difference in learning outcomes between the experimental group that used augmented reality animations and the control group. Students in the experimental group achieved higher learning outcomes. Students who learned using augmented reality animations did much better than those who didn't.

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Author Contributions

Conceptualization, AFP, APWM and ARF; methodology, AFP and KNAK; software, AFP and RRLS; validation, AFP, DGRW, APWM and ARF; format analysis, AFP and RRLS; investigation, AFP, KNAK and MH; data curation, AFP, KNAK and MH; writing—original draft preparation, AFP; writing—review and editing, AFP; visualization, AFP and DGRW; supervision, APWM, DGRW and ARF; project administration, AFP; funding acquisition, AFP, KNAK, DGRW, and MH. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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