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Article

**Development of Digital Learning Media Using Augmented Reality (AR)
for Teaching the Blood Circulation System to Class VIII A Students at
MTs Al-Manar**

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Article Info

5st AVES

Annual Virtual Conference of
Education and Science 2025

Keywords:

*Augmented Reality;
Learning Media;
Blood Circulation System;
Science*

ABSTRACT

This study aims to develop digital learning media based on Augmented Reality (AR) using the Assembler Edu/Word platform to enhance the understanding of the blood circulation system among Class VIII A students at MTs Al-Manar. The study was conducted to address the low engagement and comprehension of students caused by traditional teacher-centered methods and limited practical media. A Research and Development (R&D) approach using the ADDIE model was employed, including needs analysis, design, development, implementation, and evaluation phases. Data was collected from 30 students through observations, student response surveys, expert validation, and pretest-posttest assessments. The results showed that the AR-based media was valid, with a feasibility score of over 88%, and that student responses were extremely positive. Furthermore, there was a significant improvement in student understanding after using the media, demonstrating that the AR-based learning tool is a valid and innovative solution to enhance science education quality at MTs.

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INTRODUCTION

Science education plays a crucial role in fostering scientific literacy among students. It imparts theoretical knowledge while also nurturing critical thinking, problem-solving, and evidence-based decision-making skills. However, science education in junior high schools, particularly at Madrasah Tsanawiyah (MTs), faces several challenges, including the reliance on conventional teaching methods. Many teachers still use lecture-based, textbook-centered approaches, often without interactive media. This results in a lack of student motivation and difficulty in grasping abstract concepts.

For instance, the blood circulation system, which involves complex biological processes, requires visualization to facilitate effective understanding. Without adequate media, students often develop misconceptions. Preliminary interviews with science teachers at MTs Al-Manar revealed that limited laboratory facilities prevent students from directly observing body organs, leading to learning that is confined to theoretical knowledge. As a result, student engagement and comprehension suffer. Information and Communication Technology (ICT) advancements offer new opportunities in

education, particularly with Augmented Reality (AR). AR enables the integration of 3D virtual objects into the real world, allowing for interactive visualizations of body organs and blood flow. This immersive experience offers students a unique opportunity to explore biological systems in a tangible way.

Prior research highlights the effectiveness of AR in education. AR-based learning media significantly enhances learning outcomes and student motivation (Dewi et al., 2022). AR-based 3D media also aids students in visualizing abstract concepts (Sugiarto, 2022). In addition, the use of AR has been shown to improve student interest, resulting in high post-test achievement with an average score of 89.29% (Shofaul Hikmah et al., 2023). These findings indicate that AR holds great potential as an innovative solution in science education, especially for complex topics such as the blood circulation system.

This study is focused on developing AR-based digital learning media for teaching the human circulatory system at MTs Al-Manar. The objectives of this research are: (1) to test the feasibility of AR media through expert validation, (2) to analyze student responses to the media, and (3) to assess the effectiveness of the media in improving student comprehension through pre-test and post-test evaluations.

Literature Review

Learning Media

Learning media refers to any tool or material used to communicate educational messages, thereby stimulating students' thoughts, attention, and interest. According to Arsyad (2011), effective media serves as an intermediary between teachers and students, ensuring that information is delivered clearly and meaningfully. Properly designed media can transform abstract content into concrete forms, enhancing the overall learning process. The evolution of learning media, from print to interactive digital multimedia, has become increasingly relevant in the context of Industry 4.0, where students are expected to be more autonomous, active, and critical.

Augmented Reality (AR) in education is a technology that overlays virtual objects onto the real world in real time. AR can display 3D simulations that students can manipulate interactively, helping bridge the gap between theory and practice. AR enhances student engagement by providing a fun and immersive learning experience, while supporting various learning styles including visual, kinesthetic, and auditory (Iqbal, 2019). Previous studies have also confirmed the benefits of AR in science education, particularly in improving conceptual understanding and student motivation:

(Dewi et al. 2022) found that AR improved science learning outcomes through the visualization of body organs.

(Nugrohadhi & Anwar 2022) emphasized that AR helps in building 21st-century competencies, such as digital literacy.

(Shofaul Hikmah et al. 2023) demonstrated that AR increased students' learning interest, with an average post-test score of 89.29%.

The Blood Circulation System The human circulatory system includes the heart, blood, and blood vessels, with blood circulation divided into two parts: pulmonary circulation (to and from the lungs) and systemic circulation (throughout the body). This topic is essential for students to understand as it connects to health and helps them grasp diseases related to the circulatory system, such as hypertension, anemia, and atherosclerosis. However, students often struggle to visualize the structure of organs and blood flow due to limited media resources. AR-based media can effectively address these issues by virtually simulating body organs.

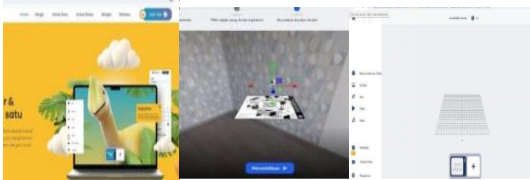
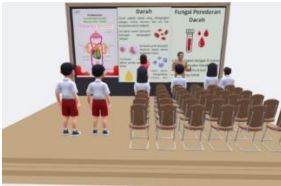
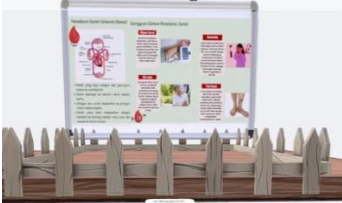
METHOD

This research utilized the Research and Development (R&D) approach, employing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The model is systematic and flexible, widely used in the development of learning media. The methodology includes:

1. **Analysis:** Identifying the needs of students and teachers regarding the teaching of the blood circulation system. Observations and interviews revealed challenges with abstract concepts and the lack of interactive media.
2. **Design:** Designing AR-based media to represent the circulatory system, including heart, blood vessels, and blood flow.
3. **Development:** Using Assembler Edu to create 3D models of the circulatory system.

4. Implementation: Conducting a limited trial with 30 students to test the usability and effectiveness of the AR media.
5. Evaluation: Gathering feedback from students and teachers through surveys and pretest-posttest evaluations.

The main displays of the AR learning media developed are shown as follows.

1  The image above shows the initial entry into the application in the form of how to log in with email, marker and application background, as well as the learning title as a warm-up for students.	2  The picture above shows the definition and meaning of the heart along with pictures of the real internal organs through which blood passes.
3  This image shows several content videos, news videos along with visuals of blood circulation and their respective functions.	4  This image explains several images of large and small blood circulation along with the meaning of blood and its function.
5  In this picture, we can see the blood vessels, audio sounds of blood circulation along with visual audio of the blood circulatory system.	6  Figure six shows blood circulation throughout the body and disorders (diseases) that occur in blood circulation.
7  On the final slide this image shows some barcodes and links to enter the Augmented reality application that will be shared with students.	

RESULT

The results of this study cover three main aspects: expert validation, student responses, and learning outcomes (pre-test and post-test). These three aspects are presented in tabular form for easier understanding and are then described descriptively to provide a comprehensive overview of the quality of the AR-based learning media that was developed.

Expert Validation

The results of the expert validation of the AR-based learning media are presented in Table below

Aspect	Content Expert	Media Expert	Language Expert	Average (%)	Category
Content/Appropriateness	90	88	87	88.3	Very Valid
Display/Design	91	89	90	90.0	Very Valid
Language	89	87	90	88.7	Very Valid
Interactivity	92	88	89	89.7	Very Valid
Average	90.5	88.0	89.0	89.2	Very Valid

Table 1.1

Expert validation of the AR-based media showed high feasibility. The content expert validated the educational content, with a score of 90.5%, ensuring that the material met curriculum standards. The media expert confirmed that the design and visual elements were highly effective, giving a score of 90%. The language expert rated the clarity and appropriateness of the language used at 88.7%. The interactivity of the media was also highly rated, with a score of 89.7%, emphasizing the importance of interactive learning.

Student Feedback

Student responses were measured through a questionnaire that included four indicators: interest, ease of understanding the material, ease of use, and increased learning motivation.

Indicator	Percentage (%)	Category
Interesting media	92	Very Positive
Facilitates understanding	89	Very Positive
Easy to use	90	Very Positive
Increases motivation	94	Very Positive
Average	91.25	Very Positive

Table 1.2

Feedback from students was overwhelmingly positive. A majority (92%) found the media engaging due to the novelty of AR and the interactive 3D models of the circulatory system. 89% of students reported that the media helped them understand the material better, particularly abstract concepts like blood flow and organ structure. Additionally, 90% of students found the media easy to use, which indicates that even students with limited technological experience were able to engage effectively. The most significant impact was seen in student motivation, where 94% reported that the AR media made learning more enjoyable and interactive.

Pretest and Posttest Results

To determine the relationship between the pretest and posttest scores, an analysis was carried out using Paired Samples Statistics, Paired Samples Correlations, and Paired Samples Test, as shown in the following table.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	76,0000	30	4,43342	,80943
	Posttest	93,6667	30	4,53594	,82814

Table 1.3

Based on the Paired Samples Statistics table, it can be seen that the students' average pretest score was **76.00** with a standard deviation of **4.43**, while the average posttest score increased to **93.67** with a standard deviation of **4.53**. The number of students who took the test was **30** at both stages. The average increase of **17.67 points** indicates an improvement in learning outcomes after the treatment was given. In addition, the relatively small standard deviations in both the pretest and posttest show that the students' scores were fairly consistent.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pretest & Posttest	30	,412	,024

Table 1.4

Based on the Paired Samples Correlations table, it can be seen that the number of students analyzed was 30. The correlation value between the pretest and posttest results was 0.412, indicating a moderate positive relationship between the two scores. This means that students who achieved relatively good scores on the pretest also tended to obtain high scores on the posttest after the treatment was given. In addition, the significance value (Sig. = 0.024), which is smaller than 0.05, shows that the relationship between the pretest and posttest scores is statistically significant. Therefore, it can be concluded that learning outcomes before and after the treatment are fairly strongly related.

Paired Samples Test

					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t-	df	Sig. (tailed)
Pair 1	Pretest-Posttest	-17,66667	4,86602	,88841	-19,48367	-15,84966	-19,886	29	,000

Table 1.5

Based on the results of the *Paired Sample t-test*, the significance value (Sig. 2-tailed) obtained was 0.000, which is smaller than 0.05. This indicates that there is a significant difference between the students' pretest and posttest scores. The mean difference of -17.67 shows that the posttest scores were higher than the pretest scores. In other words, there was a significant improvement in students' learning outcomes after the treatment or instructional intervention was given. These results prove that the intervention had a positive impact on enhancing students' understanding

The results of this study have important implications for science education. The use of AR in teaching complex biological systems, such as the circulatory system, enhances students' engagement and conceptual understanding. By providing an interactive and visual representation of abstract concepts, AR helps bridge the gap between theoretical learning and practical experiences. This aligns with previous research showing that AR significantly improves student learning outcomes and motivation (Dewi et al., 2022; Sugiarto, 2022; Shofaul Hikmah et al., 2023).

The positive impact on student motivation, engagement, and understanding further supports the integration of AR into science education. As ICT continues to play an increasingly important role in education, AR offers a unique opportunity to transform traditional teaching methods into more interactive and engaging learning experiences.

DISCUSSION

The expert validation results in Table 1.1 indicate that the AR-based learning media developed in this study has a very high level of validity and feasibility, with an overall average score of 89.2% (Very Valid). The content expert provided a score of 90.5%, confirming that the material is accurate, relevant, and aligned with curriculum standards, while also supporting students' cognitive development through interactive visualization. The media expert rated it 90%, reflecting a well-designed interface, attractive visuals, and effective use of AR technology that enhances student engagement and usability. The language expert gave 88.7%, showing that the language used is clear, communicative, and easily understood by students. Meanwhile, the interactivity aspect scored 89.7%, highlighting the active learning experience provided by AR features that encourage exploration and participation. Overall, the results in Table 1.1 confirm that the AR-based learning media is pedagogically effective, visually appealing, linguistically accessible, and highly interactive—making it a powerful tool to enhance students' motivation and conceptual understanding in science learning.

As shown in Table 1.2, student feedback on the AR-based learning media was very positive, with an overall score of 91.25%. This indicates that the media successfully attracted students' attention, enhanced their understanding, and increased learning motivation. The interest indicator scored 92%, showing that students found the AR media engaging and enjoyable thanks to its interactive 3D models of the circulatory system. The understanding indicator reached 89%, meaning the media helped clarify abstract topics like blood flow and organ structure. The ease of use score of 90% indicates that students could easily operate the media, even with limited technological skills. The highest score, 94%, was for motivation, confirming that AR made learning more fun and interactive. In summary, the results in Table 1.2 show that the AR-based learning media is effective, easy to use, and motivating. It not only improves conceptual understanding but also increases student engagement and enthusiasm during learning.

The data in Table 1.3 shows a significant increase in students' learning outcomes after using the developed AR-based learning media. The average pretest score was 76.00, while the posttest score rose to 93.67, resulting in an increase of 17.67 points. This improvement indicates that the AR media effectively enhanced students' understanding of the circulatory system material. The relatively low standard deviations in both the pretest (4.43) and posttest (4.53) suggest that students' performance was consistent, showing that the learning gains were not limited to only a few individuals but occurred across the group. The increase in posttest scores also supports the results of the student feedback, where most students expressed that the AR media made learning more interesting, easier to understand, and motivating. Overall, these findings confirm that the use of AR-based media positively impacts both student engagement and learning outcomes, making it an effective tool for improving conceptual understanding in science learning.

The data in Table 1.4 shows that the correlation between students' pretest and posttest scores was 0.412 with a significance value of 0.024 (< 0.05). This result indicates a moderate positive and statistically significant relationship between the two tests. In other words, students who achieved good scores on the pretest also tended to score higher on the posttest after learning with the AR-based media. This demonstrates that the improvement in students' learning outcomes was consistent across the group, not random or incidental. The statistically significant correlation value also supports the effectiveness of the AR-based learning media in enhancing students' understanding, as it shows that prior knowledge was successfully strengthened and developed through interactive AR experiences. Thus, the findings confirm that the use of AR media contributes positively to students' learning progress and conceptual mastery.

The data in Table 1.5 shows the results of the Paired Sample t-test, where the significance value (Sig. 2-tailed) is 0.000 (< 0.05), indicating a significant difference between students' pretest and posttest scores. The mean difference of -17.67 demonstrates a substantial increase in students' performance after the use of AR-based learning media. This result confirms that the AR intervention effectively improved students' understanding of the circulatory system material. The findings suggest that AR media provides meaningful learning experiences by combining visualization and interactivity, allowing students to better grasp abstract biological concepts. The visual and hands-on features of AR enable learners to explore the circulatory system more concretely, thus enhancing conceptual comprehension and retention. Moreover, the improvement in posttest scores aligns with previous studies (Dewi et al., 2022; Sugiarto, 2022; Shofaul Hikmah et al., 2023), which reported that AR significantly boosts student engagement, motivation, and learning outcomes. Overall, the significant

increase in learning achievement and motivation highlights the potential of AR technology as an innovative tool in science education. It bridges the gap between theory and practice, making complex scientific topics more interactive, engaging, and accessible to students.

CONCLUSION

The AR-based digital learning media for teaching the blood circulation system proved to be highly valid and effective. The media significantly increased student engagement, comprehension, and motivation. Expert validation and student feedback indicated that the AR media was an effective tool for enhancing learning outcomes. This study demonstrates the potential of AR to transform science education, providing students with an immersive and interactive experience that helps them better understand complex biological systems.

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