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IMMERSIVE LEARNING OF HUMAN BLOOD CIRCULATORY SYSTEM THROUGH AUGMENTED REALITY

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Abstract

The human blood circulatory system is one of the topics discussed in the standard 5 science syllabus. However, integration of Augmented Reality (AR) technology into science education presents a promising solution to address limitations highlighted by Yean (2019), particularly the difficulty that students face in understanding due to limited visualization experiences. This project aims to solve this problem by creating a learning tool by using Augmented Reality (AR) for primary school students. It uses the ADDIE methodology to design and implement an engaging AR-based learning tool. By enhancing educational engagement and effectively conveying complex scientific concepts, the application not only captivates learners but also improves comprehension. In addition, System Usability Scale (SUS) questions by Sari and Henim (2021), are used to underscores the need for educational applications to enrich learning experiences and enhance realism in depicting anatomical structures. The findings indicate that this innovative approach not only makes education more captivating but also significantly enhances the effectiveness of comprehension of complex scientific concepts. Moreover, future work aims to further enhance the application's appeal and the realism of its models, ensuring students gain a deeper understanding of organ structures and functions within the body, thereby creating a more immersive and educational experience for users.

Keywords: Augmented Reality, educational, visualization

INTRODUCTION

In today's world, the significance of science education cannot be overstated. Among all the topics explored within science curricula, the study of the human body stands as a captivating journey into the intricacies of anatomy and physiology. However, the entire journey of the circulation process makes it challenging for students to understand using reading material

alone. Schoenfeld et al. (2022) also stated that traditional methods do not effectively help students understand the structure of scientific knowledge. Various research fields suggest that AR can be used in schools where the use of this technology is still very limited for primary school students (Pellas et al., 2019). Additionally, students need to be exposed to something that would trigger their imagination and critical thinking (Mara & Mohamad, 2021) due to the lack of visualization experience in the learning process. This kind of platform designed for high school and university students is more common, but primary students do not have the opportunity to learn using AR (Pellas et al., 2019), which should ideally make learning more enjoyable.

By using AR technology, it is such a valuable tool for learning, especially in complex topics such as the human blood circulatory system found in standard 5 science syllabus. This technology had the potential in the education field as it gave a dynamic learning environment and new methods of learning. So, students could learn with more enthusiasm. Furthermore, AR technologies became widely available and portable on mobile devices over the last several years, making it easy to access both in and outside the classroom.

With the help of AR technology in this project, it enhanced traditional teaching methods and helped standard 5 students to focus more when they learn the human blood circulatory system more enjoyably and effectively.

LITERATURE REVIEW

Science is often related to technology as these fields are interconnected with each other, enhancing human capabilities through the development of tools, machines, and systems that have become integral to daily life. Effective science education is crucial for cultivating future scientists, thinkers, and problem solvers. Traditionally, anatomy education relied on textual materials and 2D diagrams, but interactive elements, such as those offered by AR technology, can make learning more engaging and effective (Wang et al., 2020), particularly for complex topics like the human circulatory system.

The Human Blood Circulatory System

Humans are an example of organisms that have a closed circulatory system. The human circulatory system is a vital network of organs and vessels that is responsible for the transportation of oxygen, water, waste material such as carbon dioxide and provide essential

nutrients throughout the body. It consists of the heart, lung, blood vessels which include arteries, veins and capillaries and also blood. Figure 1 shows the human blood circulation transportation.

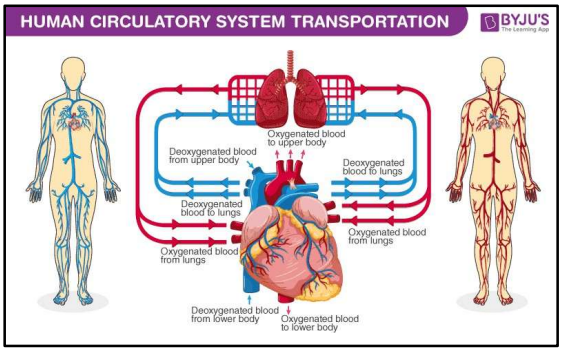

Figure 1: The Human Blood Circulatory System

Issues Regarding Learning Human Blood Circulation System

Learning about the human blood circulatory system in schools presents several challenges, as noted in recent studies. This topic can be seen as hard for students, especially for those who are first time learners. The language used in scientific texts is often dense and technical, posing a barrier to understanding. Strohmaier (2023) highlighted that the specialized vocabulary and complex sentences in biology textbooks make it difficult for students to grasp the material effectively.

Moreover, the effectiveness of teaching methods plays a crucial role. Traditional didactic approaches often fail to engage students or cater to diverse learning styles. Interactive and hands-on learning aids, such as three-dimensional models, have been shown to significantly improve student understanding and engagement. Munna and Kalam (2021) demonstrated that using three-dimensional visual aids in teaching the human circulatory system can enhance students' learning outcomes by providing a tangible and interactive way to explore the concepts.

Addressing these issues requires a multifaceted approach that includes revising curriculum materials to simplify the language, incorporating interactive and visual aids into lessons, and leveraging technology to create more engaging and effective learning experiences.

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METHODOLOGY

The ADDIE methodology was selected as the most suitable framework for developing CircuVision, an AR-based learning application for the blood circulatory system. This model's systematic approach and ease of use make it ideal for this project. The development process will begin with modeling the organs involved in the human circulatory system and culminate in a fully functional learning application.

Figure 2 shows the flowchart for the AR learning application, CircuVision, where it shows the step-by-step process of user interaction, starting from the launch of the application to the completion of the learning modules, including some quizzes.

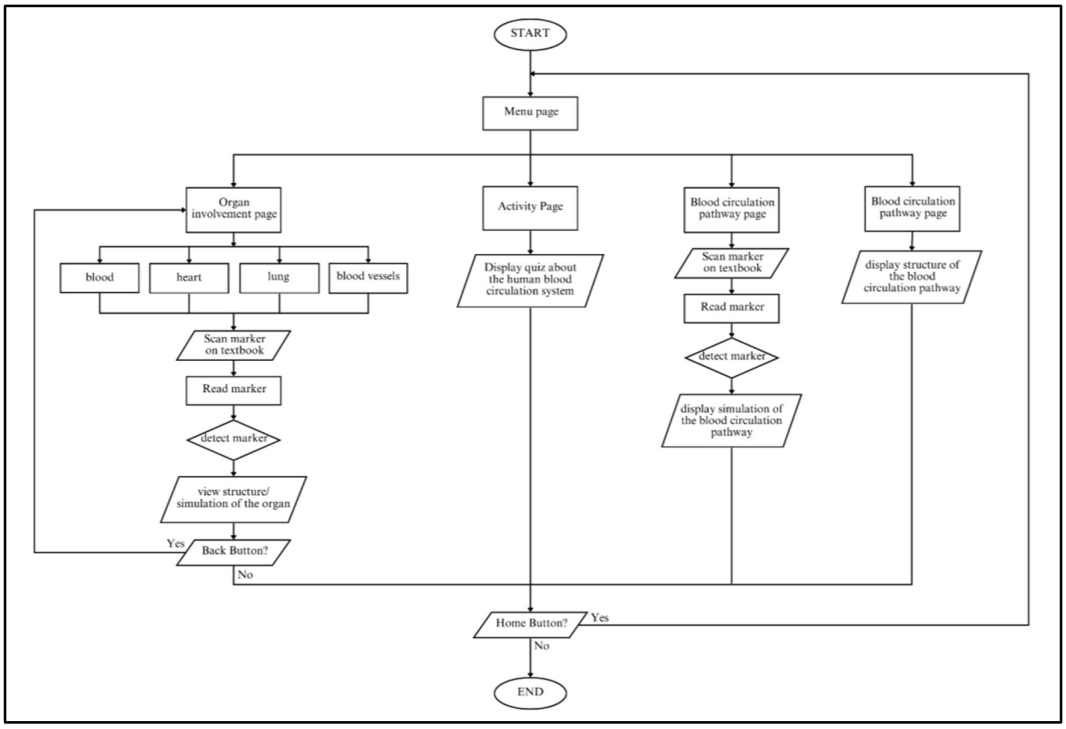

Figure 2: Flowchart for CircuVision

RESULT AND DISCUSSION

This section discussed the feedback that gathered from a total of 30 users. Users that were involved in this survey answered the questions which were based on SUS questions after they had used the application. Table 1 shows the questionnaires that were answered by the user. The questionnaire consists of eight questions, each rated on a measurement scale from 1 to 5, where 1 represents strong disagreement and 5 represents strong agreement.

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Table 1: The summary of the questionnaires

No.	Question	Measurement Scale				
		1	2	3	4	5
Q1	I found this application was easy to use.				4	26
Q2	This application did not help me understand the human blood circulatory system well.	27	2	1		
Q3	The AR visuals in the application were clear and easy to see.				1	29
Q4	I feel that I need assistance from others to use this application.	19	8	3		
Q5	I think this application made learning more fun than regular textbooks.					30
Q6	I think this application is difficult to use.	25	5			
Q7	The interactive features in this application were well-designed and helped me learn more easily.			2	5	23
Q8	I thought there was too much inconsistency in this application.	26	4			
Q9	The information in this application was presented in a way that was easy to understand.				4	26
Q10	I need to learn many things before I can use this application.	27	3			

From the data collected in table 1, it can be concluded that this application received very positive feedback from the users, particularly regarding ease of use, clarity of AR visuals, enjoyment and the effectiveness of its educational content.

By using the formula from the System Usability Scale (SUS), the user's responses need to be calculated. In order to get accurate results, each of the 8 questions in the SUS questionnaire must be scored individually. The scoring process starts with the conversion of the scale into numbers for each of the 8 questions. The formula was shown in Figure 3.

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Step 1 : Convert the scale into number for each of the questions

Strongly Disagree: 1 point
Disagree: 2 points
Neutral: 3 points
Agree: 4 points
Strongly agree: 5 points

Step 2: Calculate using the formula

X = Sum of the points for all odd numbered

Figure 3: The formula to calculate SUS result

For all the odd numbered questions, X was used to calculate the expression and subtract 1 from the user's response to achieve the same transformation. Meanwhile, Y was used to calculate the expression for all the even numbered questions and subtract the user's response from 5 to get all the scores. Once the scores for all 8 questions are obtained, sum them up to get a total score ranging from 0 to 40. To convert this total score, multiply the sum by 2.5. Figure 4 shows the calculation to find SUS score for the first user and table 2 shows the SUS score for all the users that answered the survey.

Odd numbered question, X = [(5+5+5+5+5) - 5]
= 20

Even numbered question, Y = [25 - (1+1+1+1+2)]
= 19

SUS Score for the first user = (20 + 19)*2.5
= 97.5

Figure 4: The calculation for the first user

Table 1: The SUS score for all the users

User	SUS Score	User	SUS Score
User 1	97.5	User 16	100
User 2	82.5	User 17	95
User 3	92.5	User 18	100

User 4	92.5	User 19	90
User 5	97.5	User 20	95
User 6	92.5	User 21	100
User 7	92.5	User 22	100
User 8	100	User 23	100
User 9	95	User 24	100
User 10	100	User 25	100
User 11	97.5	User 26	100
User 12	87.5	User 27	100
User 13	100	User 28	92.5
User 14	100	User 29	97.5
User 15	87.5	User 30	95

Total SUS Score = (97.5 + 82.5 + 92.5 + 92.5 + 97.5 + 92.5 + 92.5 + 100 + 95 + 100 + 97.5 + 87.5 + 100 + 100 + 87.5 + 100 +95 +100 + 90 + 95 + 100 + 100 + 100 + 100 + 100 + 100 +100 + 92.5 + 97.5 + 95) / 3000

= 2880/ 3000

= 0.96 @ 96

Figure 5 shows a visual interpretation of the SUS scores and how to measure the user satisfaction and acceptance.

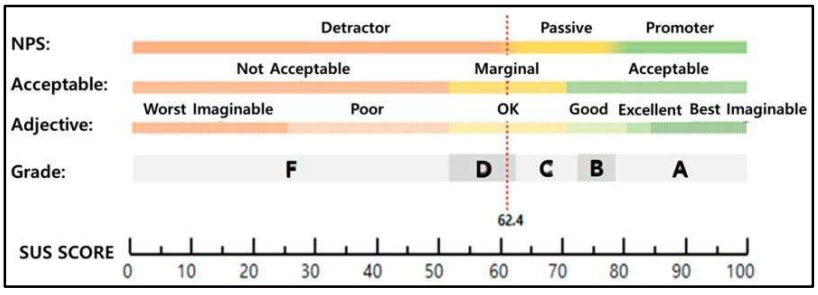

Figure 5: SUS score measurement

This application has a total score of 96 which is tested by System Usability Scale (SUS). This final SUS score provides a reliable measure of usability, where higher scores indicate a better usability.

CONCLUSION

CircuVision is an AR learning application designed for standard 5 students to enhance their understanding of the human blood circulation system in the Science subject. With the advent of advanced technology, this application has been successfully developed with the hope of providing a positive impact on the users by making learning about the human blood circulatory system more engaging and interactive. Moreover, this application offers users the opportunity to experience a different way of learning beyond traditional materials like paper and textbooks.

By incorporating augmented reality, CircuVision represents a substantial advancement in educational technology, which not only makes learning more enjoyable but also helps students understand complex concepts more easily. This innovative approach offers students an impactful way to learn about the human blood circulatory system.

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