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Developing Learning Media based on AR-VR to Enhance Junior High School Students' Understanding of Human Digestive System Materials

Zainur Rasyid Ridlo*, Rayendra Wahyu Bachtiar, Sri Wahyuni, I Ketut Mahardika, Iwan Wicaksono, Silvi Putri Ayu Ningsih, Efrika Marsya Ulfa, & Nurul Iqdami Zuniari

Department of Science, University of Jember, Indonesia

Abstract: The research aims to develop an Android-based Augmented-Virtual Reality learning medium on digestive system materials for junior high school on human digestive system materials. The study implemented an instructional design model based on ADDIE, with eight classroom meetings to assess student learning outcomes. Pretest and posttest scores were used to calculate the N-gain score, reflecting the students' improvement in understanding the material. The study involved 40 students. The results showed a significant improvement in student performance, with an N-gain score of 0.62, indicating moderate learning gains. The practical application of the media was deemed feasible, and students reported high levels of engagement and satisfaction with the media. These findings suggest that the learning media effectively supported the students' comprehension and engagement in science, and the use of the ADDIE model provided a structured approach to assessing its impact on learning. The creation of Augmented-Virtual Reality on Assemblr edu and MilleaLab application also seems simple so that it can be easy for developers to create the desired material.

Keywords: learning media, augmented-virtual reality, assemblr edu, millealab, ADDIE

▪ INTRODUCTION

One of the foundations for the integrity and progress of a nation, the state is education. The better the quality of education in a nation, the better the quality of the nation. Education itself will be successful if supported by a good and quality learning process. Countries see education as an essential tool to achieve common goals. They are able to make education more accessible to all citizens. For this reason, education is designed with standards that include the learning environment, skills training, tools, teaching methods, as well as learning objectives and content. Education is now a vast, accessible, and growing public service (Karataş, 2022). Educators in the digital era are expected to utilize technology to create effective learning. The rapid development of technology has changed the way of living, learning, and working, with the hope of improving the quality of life, including in education. Technology-based multimedia, such as audio-visual and internet, supports learning by improving student learning outcomes, effectiveness, independence, and productivity (Puspitarini & Hanif, 2019).

Technology, as a result of the development of science, is now an important part of education. Its use supports learning, both as a source of information and a learning aid. The integration of technology also helps develop 21st-century skills, such as problem-solving, critical thinking, collaboration, and digital literacy, which are essential for students' future success. Digital tools and online platforms make it easier to access information, train collaboration, manage projects, and convey ideas digitally, skills needed in the era of a technology-based global economy (Widyasari, 2024). The use of technology in the world of education can be utilized through processes and products to solve an educational and learning problem, while paying attention to aspects of

Zainur Rasyid Ridlo
*Email: zainur.fkip@unej.ac.id

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technological excellence in learning, the right strategies can be devised to improve the quality and effectiveness of learning. The use of other technologies in the field of education is as a medium of learning.

Smartphones can be used as an interesting and fun learning medium if filled with applications and educational content. In learning, teachers can use visualization strategies by utilizing images to strengthen students' understanding. One of the latest innovations is Augmented-Virtual Reality-based learning media. (Zuniari et al., 2022). Augmented Reality is the incorporation of digital images into 3D objects that can be added to the real world, can follow the state of the environment in the real world, and can be used on mobile devices (Saputro and Dhanar,2015).

Virtual Reality or VR is a technology that represents the real world in the computer world by displaying a 3D environment using special electronic equipment (Hariyanto & Köhler, 2020; Kandakatla et al., 2020). Many benefits have been reported with VR-based instruction, such as improved academic performance (Lee and Wong 2014), active learning (Kim et al. 2001), improved spatial capability (Cohen and Hegarty 2014), visualization (Manseur, 2005), and even it is can provide collaborative learning (Ho et al. 2011). In the world of education, Augmented Reality (AR) is a technology that combines the real world with 3D virtual objects generated by computers, allowing users to interact through devices such as mobile phones. AR adds virtual information to the real environment in real time, creating a more engaging and interactive visual experience (Fitria, 2023). The use of Augmented-Virtual Reality technology, especially on mobile devices, is still relatively minimal. This technology has great potential to enrich telecommunications to be more effective.

Assemblr Edu is one of the applications on mobile devices that apply Augmented Reality technology. Assemblr Edu is an android application that can be used to create a 3D object where the object can also be applied as Augmented Reality or only seen as a 3D object. In the Assemblr edu, there are facilities such as classrooms that can be used in the world of education to allow teachers and students to communicate with each other and also display 3D media that have been created (Assembler, 2020). Assemblr Edu is an online education platform that leverages augmented reality, artificial intelligence, and other advanced technologies. The platform allows users to create and edit a variety of learning materials from a wide variety of topics. With 3D and AR features, Assemblr Edu supports educators in creating interactive, engaging, and accessible learning experiences (Carrión-Robles et al., 2023).

MilleaLab is one of the Virtual Reality (VR) platforms that can support the creation and access of 3D-based educational content and Virtual Reality (VR) simply, quickly, and affordably (Cahyaningtiyas, 2020). According to (Agusty & Anggaryani, 2021), the Millealab application is a tool for creating VR media with easier access to create realistic visualizations to support the teaching and learning process. MilleaLab is an open-access tool and can be accessed by anyone who wants to use it both online and offline as well as interactive VR-based content. Students can access it through three ways using the MilleaLab Viewer on smartphones, namely VR, 360, and non-gyro, which allows students to access content interactively and realistically (Sari et al., 2023). The MilleaLab application has several features, one of which is the "Explore" feature which contains several subjects from junior high to high school that can be accessed via smartphone without any charge (Alkahfi et al., 2024).

The material about the human digestive system is difficult to observe directly because most of it is in the body. The use of conventional visual aids is still limited because it cannot display blood flow, heart rate, or other organs working in the body. Therefore, the application of AR and VR in Biology can be a solution to these obstacles. With AR, students can view organs in a 3D form that can be rotated and studied in more detail, while VR provides a virtual exploration experience of the digestive process, including blood flow and heart rate in real life. This technology makes learning more immersive, interactive, and engaging and makes it easier to understand complex concepts more thoroughly and practically (Fitria, 2023).

Based on this description, the researcher wants to develop interactive learning media based on AR and VR as an alternative learning media, to ensure that the development of this media is in accordance with the learning needs of the digestive system. Thus, it is hoped that learning media that is interactive, effective, and feasible to use can be created to improve student's understanding in the learning process because this media allows the material to be easier to understand visually and provides a more in-depth and interesting learning experience.

▪ METHOD

Participants

The participants in this study consisted of 40 junior high school students who were actively involved in the research, providing valuable insights into the effectiveness of the learning media. In addition to the students, the research also included 3 validators and 3 observers, whose roles were crucial in assessing the validity of the learning media and observers to observe during the learning media implemented into a classroom, as well as in monitoring the implementation process to ensure accurate and objective data collection.

Research Design and Procedures

Based on the description, researchers wanted to develop interactive learning media as an alternative to the selection of interactive learning media. In addition, this research is also needed so that the development of Augmented-Virtual Reality learning media is by the needs in learning. Thus will be obtained the Augmented-Virtual Reality learning media that are interactive and worthy of use in the learning process. The research model used is the ADDIE model from the branch in 2009.

Table 1. Media development stages

Stages	Process
Analysis	● Curriculum Analysis ● Student Characteristics Analysis ● Technology Analysis ● Infrastructure Analysis
Design	● Material Determination ● Flow Chart Creation
Develop	● Product Manufacturing Process
Implementation	● Application of products into learning
Evaluation	● Evaluation of the results of the application of the product

In an application in research, the ADDIE model only reaches the development stage only because this research discusses the learning product development process. A detailed explanation of the development of Augmented-Virtual Reality media in the table above is as follows:

Analysis

The analysis stage aims to analyze the need for the development of Augmented-Virtual Reality media assisted by Assemblr edu applications and MilleaLab application. The analytical stages are based on curriculum analysis, student characteristic analysis, technology analysis, and analysis of infrastructure.

Curriculum analysis is conducted to ensure that the curriculum used in the school aligns with the material, indicators, and objectives that will be applied to meet the basic competencies. This process helps identify the content that needs to be taught and ensures that the development of learning media is under the curriculum's framework.

Student characteristics analysis is carried out to understand the specific characteristics of the students. This is important so that the media developed can be tailored to suit the student's needs. The data for this analysis is gathered by observing classroom activities, interviewing science teachers, and reviewing relevant theories. This analysis covers general characteristics such as age, gender, cultural background, and the number of students in each class, as well as their current location.

Technology analysis is essential to determine the technological tools that can be applied in the learning process. This involves observing existing technologies and conducting interviews with science teachers about the use of technology in their teaching practices. This analysis helps identify the necessary features for developing an android-based Augmented-Virtual Reality learning medium.

Infrastructure analysis is performed to assess the available facilities and infrastructure in the school. This ensures that the necessary resources are in place for the successful implementation of the learning product. This includes evaluating the availability of mobile phones for learning, internet access or Wi-Fi networks, and other support systems that enable the product to function effectively in the learning environment.

Design

The analysis that has been done obtained data that will be used to design the product. The design of this product is processed from the results of the analysis of media needs that have been done. The step-by-step procedure for using the Assemblr Edu app to create and display 3D objects through Augmented Reality technology is as follows: first, the initial step is to install the Assemblr Edu app on the device being used. Once the app is installed, the user can begin collecting the 3D objects needed for the lesson. This collection process can be done by selecting relevant 3D objects related to the material to be presented.

After collecting the objects, the next step is to create the 3D objects. The user can design the objects using the features available in the app, adjusting the shape and appearance of the objects according to their needs. Once completed, the 3D object is saved as a file to be used in the next steps. Next, the user needs to print the marker required to display the 3D object in the app. This marker is used by the app to recognize and project the object into the real world using Augmented Reality technology.

Once the marker is printed, the next step is to scan the marker using the device's camera. This scanning process allows the app to detect the marker and link it to the previously created 3D object. After scanning, the app will check if the 3D object matches the one that was created earlier. If the 3D object matches the marker, the app will display the 3D object on the device screen. Finally, after the 3D object is successfully displayed, the process is complete and can be concluded. With these steps, users can utilize Augmented Reality to provide an interactive and engaging learning experience.

Develop

Developing learning media is very important for the advancement of learning, therefore we develop Augmented-Virtual Reality learning media that is assisted by Assemblr edu applications and MilleaLab application. Developing Augmented-Virtual Reality learning media using the Assemblr edu application and MilleaLab application is very simple and practical. This is because the features contained in the Assemblr edu application and MilleaLab application make it easy for us to create Augmented-Virtual Reality, menus - menus contained in this application are classes (to share the results of 3D object creation to class members), topics (to see Augmented-Virtual Reality from some of the materials provided), scan (to scan markers) and you (there are project features intended to create the Augmented-Virtual Reality that we want).

In the preparation phase, the first step is to download and install the *Assemblr Edu* app. This app is used to create 3D objects that will be incorporated into the learning media. Next, gather the necessary materials to create the 3D objects, such as relevant models related to the educational content to be taught. Once the app is installed and the materials are ready, the next step is to open the app and select the project menu to begin creating the 3D objects. Here, users can design the 3D objects according to their preferences and learning needs.

After completing the design and ensuring it meets the requirements, save the 3D object for further use. If necessary, 3D objects can also be uploaded from websites that offer various 3D models that can be used within the app. Once the objects are ready, the next step is to print markers that will be used to scan the 3D objects within the AR-based learning media. These markers serve to link the real world with the digital objects that have been created.

In the trial stage, the printed markers are then scanned to check if the 3D objects appear correctly. Once the marker is successfully scanned, the 3D objects will appear in the classroom, offering a more interactive and engaging learning experience for students. This process enables AR and VR-based learning, presenting the material in a visual form while deepening students' understanding in an immersive and easily comprehensible way.

Implementation

The implementation of this research follows the ADDIE Model, a systematic instructional design framework that ensures the effective application of the learning interventions within the science classroom. A total of eight classroom meetings were organized, where students' understanding of the material was assessed through pretests before the first session and post-tests after the final meeting. These assessments provided a quantitative measure of the student's progress and the effectiveness of the implemented learning strategies. During the entire implementation process, three trained observers were present at each meeting to monitor and analyze the classroom environment, the use

of learning media, and the overall teaching methodologies employed. Their role was to collect qualitative data on the success of the interventions and to assess how well the media and instructional techniques were integrated into the lessons. The observers' feedback played a crucial role in refining the approach in real-time, ensuring continuous improvement. At the last meeting, students were asked to complete a comprehensive questionnaire, which included questions about their responses to and experiences with the learning media used throughout the study. The questionnaire provided critical feedback on how the media affected their learning experience, engagement, and understanding of the science material, contributing valuable insights to evaluate the overall effectiveness of the instructional design.

Evaluation

The pretest and posttest scores will be analyzed to assess the N-gain score, providing a measure of students' learning improvement and the effectiveness of the learning media in enhancing their understanding. Lastly, the students' responses to a questionnaire will be analyzed to evaluate the effectiveness of the media in terms of engagement, usability, and how well it supported their learning experience. These results will evaluate how far Augmented – Virtual Reality enhances the students' understanding of the human digestive system in science material.

Instrument

This research is a quantitative study using cognitive test instruments in the form of pretest and posttest questions that have been adapted to the material of the human digestive system. Indicators of understanding of the digestive system are oriented towards students' higher order thinking skills which include the ability to analyze, evaluate, and create. The questions given to students totaled five questions related to mechanical and chemical digestion, each question containing questions oriented to the ability to analyze, evaluate and create. The expected analytical ability is to analyze the working system of human digestion, the expected evaluation ability is the ability to evaluate the concepts that exist in the process of digestion in humans, while at the stage of creating the ability measured is the of students to create conclusions about the human digestive system.

The second analysis uses a questionnaire to measure practicality and effectiveness of learning media. Questionnaire to measure practicality score filled by observers during observing teaching and learning in classroom and questionnaire to analyse students' responses after using Augmented-Virtual Reality as learning media used to measure effectiveness. Questionnaire of students' responses involves four indicators with ten questions in total, it is about usage of learning media such as design of learning media with four questions, accessibility with three questions, novelty of integration technology with two questions and compatibility with subject material with two questions.

Data Analysis

The data collection procedure employed in this research is that of validity, practicality, and effectiveness of learning media. The data obtained from the questionnaire administered to expert validators and observers were analyzed using a Likert scale of 1-5 with a response description. This scale ranged from 5 to 1, indicating that the predicate was "very good" to "very poor". The results of the validity, practicality, and effectiveness scores of the module will be aligned with the category that can be seen

in Table 2.

Table 2. Category of score

Range Score (%)	Criteria
85 - 100	Very Good
69 - 84	Good
53 - 68	Neutral
37 - 52	Poor
20 - 36	Very Poor

On the other hand, students' pretest and posttest scores will be analyzed with paired sample T-test with Jamovi software and the N-gain formula and the N-gain score will be aligned with the category as Table 3.

Table 3. Criteria of N-gain

Range Score	Criteria
$0.7 \leq gain \leq 1$	High
$0.3 \leq gain < 0.7$	Moderate
$0 \leq gain < 0.3$	Low

▪ RESULT AND DISSCUSSION

From the implementation of the analysis, design, development and implementation stages, Augmented-Virtual Reality results are obtained in the material of the human digestive system. The results obtained are in accordance with the objectives, looking for validity, practicality and effectiveness of Augmented-Virtual Reality. Augmented Virtual Reality is produced in relation to digestive organs, namely there are organs of the mouth, esophagus, stomach, small intestine, large intestine and anus, as well as additional digestive organs such as organs of the pancreas and organs of the liver. There is also Augmented Virtual Reality about the nutrients needed by the human body, and there are also several custom markers that are used during learning. The results of ADDIE model will explain further below

Analyze

The analysis stage has been successfully carried out as a first step in the development of Augmented-Virtual Reality learning media by utilizing the Assemblr edu and MilleaLab applications. This analysis not only aims to ensure the suitability of learning media with curriculum needs, student characteristics, technology, and infrastructure, but also to identify problems that exist in schools that are the basis for the development of this learning media. The results of observations and interviews with teachers show several significant problems in the learning process at school, especially in the material of the human digestive system, namely: Difficulty in Visualizing Abstract Concepts, The material of the human digestive system is often considered difficult for students to understand because it involves abstract concepts, such as organ function, chemical processes, and digestive mechanisms. Conventional learning media, such as textbooks and two-dimensional pictures, are not able to provide a real picture to students. Lack of Interactive Media, Interactive and interesting learning media facilities in schools are still limited. Teachers often use lecture and presentation methods without the support

of media that are able to attract students' attention or increase their engagement in learning. This results in low interest in learning and understanding of students. Obstacles to Online Learning, during the implementation of online learning, many students have difficulty staying focused. Existing learning media are not able to present an interesting and in-depth learning experience, so students lose motivation to learn independently. Limited Infrastructure and Access to Technology, Although most students have devices such as smartphones, not all schools have adequate internet access. In addition, the lack of training for teachers in utilizing learning technology is another obstacle in the use of technology-based media.

The implementation of needs analysis is carried out to identify problems faced in schools and ensure the development of AR-VR-based learning media in accordance with the curriculum, student characteristics, available technology, and supporting infrastructure, so that it can answer learning needs effectively and efficiently. Curriculum Analysis, curriculum analysis has ensured that the learning media developed is aligned with the established basic competency standards. With a focus on indicators that demand an in-depth understanding of the material, AR-VR media is designed to support students in visualizing and understanding abstract concepts that are difficult to explain conventionally. Student Characteristics Analysis, data collection through observation, interviews, and theoretical studies showed that students had a high interest in technology, such as games and interactive visual-based applications. This characteristic is the basis for designing media that utilizes AR-VR in order to increase students' interest and motivation in learning. Technology Analysis, although technology such as smartphones is available, its use in learning is still minimal. This analysis drives the development of AR-VR media that is compatible with existing devices, making it easily accessible to students and teachers. Infrastructure Analysis, despite the limitations of some schools, the results of the infrastructure analysis show that the development of AR-VR-based media is still possible with some adjustments, such as the use of offline applications to support schools with limited internet access.

The development of AR-VR-based learning media is based on various problems faced in schools, such as difficulties in visualizing materials, lack of interactive media, and obstacles in online learning. By carrying out an in-depth needs analysis, the researcher ensures that the AR-VR media developed is not only relevant to the curriculum but also able to answer these problems. This learning media is expected to increase students' understanding of the human digestive system material with a more interesting, interactive, and innovative approach.

Design

The design stage is a follow-up step after the needs analysis, where the design of learning media based on Augmented-Virtual Reality (AR-VR) is prepared based on the results of analysis, learning outcomes, and indicators on the human digestive system. At this stage, the structure of the learning media begins to be designed by arranging a systematic learning flow, starting from the introduction of basic concepts to interactive exploration using Augmented-Virtual Reality technology.

Augmented-Virtual Reality is produced regarding digestive organs, namely, there are organs of the mouth, esophagus, stomach, small intestine, large intestine, and anus as well as additional digestive organs such as pancreas organs and liver organs. There is also

Augmented-Virtual Reality about the nutrients needed by the human body, in addition, there are also several custom markers that will be used during learning as Figure 1

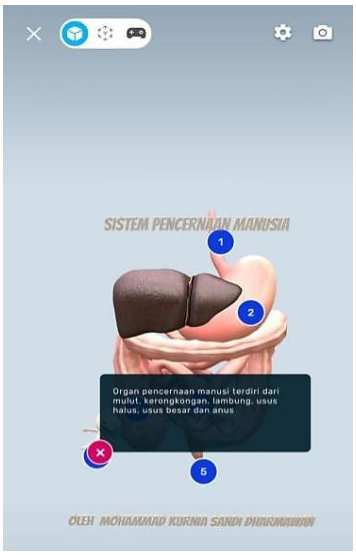

Figure 1. 3D object results

3D results can only be seen in applications and edu assemblers, this 3D form does not display Augmented Reality in the real world. The results of this 3D form in the application can be accessed in the "class" menu if you have entered the shared class or can be accessed in the "topics" menu.

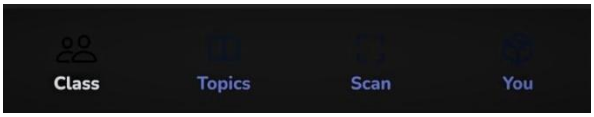

Figure 2. Menu on edu assembler application

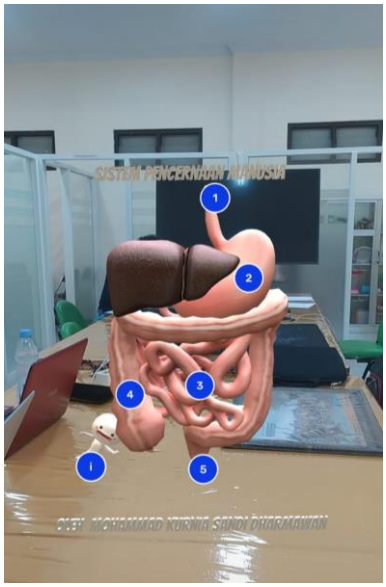

Figure 3. Augmented Reality without the use of a marker

The results of Augmented Reality without marker scans are first directed to find the place to build 3D objects as presented in Figure 3 above and the results using scan markers presented in Figure 4. Either with and without a scan marker, 3D objects can be used properly . This augmented result is the same as the 3D result, but where the object is placed is different, this Augmented Reality can be placed in the real world which will later impress in the real world and real-time

Figure 4. Augmented Reality using scan markers

Augmented Reality results using scan markers are almost the same as Augmented Reality results without using marker scans, only what distinguishes the process. The process of performing Augmented Reality results by using this marker can only be used in Assemblr edu applications that are paid for in the "scan" menu, of course, there must also be a marker of the 3D object that has been created.

The design of appropriate learning media is very important for the advancement of learning. Therefore, we designed Augmented-Virtual Reality learning media assisted by the Assemblr edu application and the MilleaLab application. Research conducted by (Mustaqim and Nanang,2017) states that the use of augmented media reality in the learning process can facilitate the creation of interactive students with teachers because Augmented Reality media is still fairly new in the student experience to increase student interest. Creating Augmented Reality learning media using the Assemblr edu application is very simple and practical, this is because the features contained in the Assemblr edu application make it easy for us to create Augmented Reality, menus - menus contained in this application are classes (to share the results of 3D object creation to class members), topics (to see Augmented Reality from some of the materials provided), scan (to scan markers) and you (there are project features intended to create the Augmented Reality that we want). On the other hand, using the MilleaLab application, students can access through three ways using the MilleaLab Viewer on smartphones, namely VR, 360, and non-gyro, which allows students to access content interactively and realistically (Sari et al., 2023).

The creation of Augmented Reality in the Assemblr edu application is located on the "You" menu as Figure 5 below, which in this menu contains project features. On the

project features, we can create Augmented Reality that suits what we want. In the project feature, there are also two features, namely a simple editor (to create 3D objects with objects that are already available) and a classic editor (to create 3D objects from scratch) as shown on Figure 6 below.

Figure 5. "You" menu on Assemblr edu app

Figure 6. Simple editor features and classic editor

In the simple editor feature, there will be many 3D objects that are reviewed in the application. We just float or process the 3D objects into the 3D shape that we want. We can also input the 3D object data we need from outside the application, such as inputting objects from other applications or from objects that we download on the website. The Assemblr edu application can also augmented reality markers created in the application. In this study, we developed the medium of Augmented-Virtual Reality by taking digestive system material from middle school students on the topic of digestive organs in humans. The material of the human digestive system is still abstract for students, this is because the digestive organs in humans are difficult to be seen directly by students in school, and also to present props cost more. Other media such as images and videos feel un-interactive to apply to students. Therefore, developing a medium of Augmented-Virtual Reality learning can later make students see in 3D form the digestive organs in humans so that students no longer guess how the digestive organs are in humans. The results of the development of Augmented Reality learning media in presented Figure 7 below.

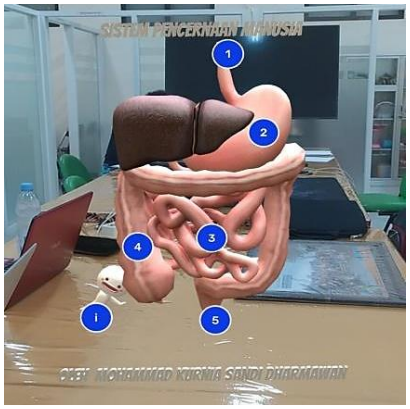

Figure 7. Result augmented reality

On the other hand, 3D object design used with Virtual Reality using MilleaLab application showed overall results of the human digestive system as shown in Figure 8. Based on Figure 8 below, human digestive system shown from mouth, esophagus, stomach, small intestine, large intestine and anus, all of these organ shows through "Play in VR" feature.

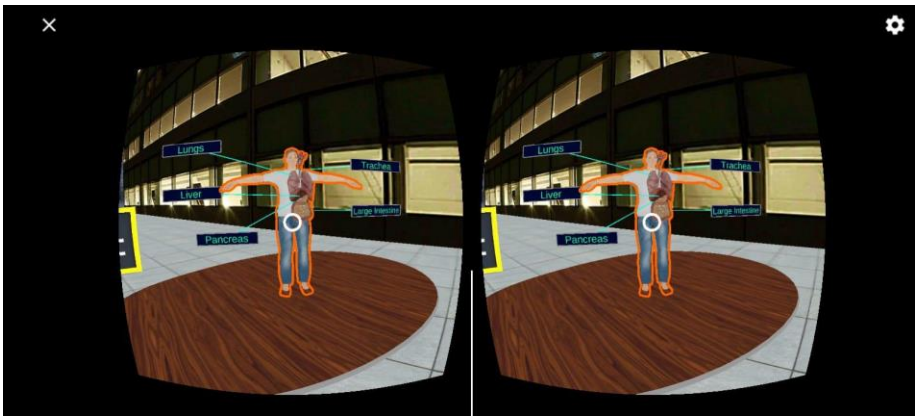

Figure 8. Result in virtual reality

Develop

After designing the media, this media is developed by going through the validation stage to ensure that the learning media has a valid category and is suitable for application in science classrooms and used by students. The validity score was analyzed based on six main categories: content validity, concept validity, construction validity, language validity, layout validity, and technological novelty validity. Each category achieved a score in an acceptable range to excellent, with the validity of the construction and the novelty of the technology standing out as very strong. Overall the validity score was 90% in the very valid category, this result shows that the learning media is well designed to improve students' understanding of the human digestive system in science learning. The validity score results are presented by Figure 9 below.

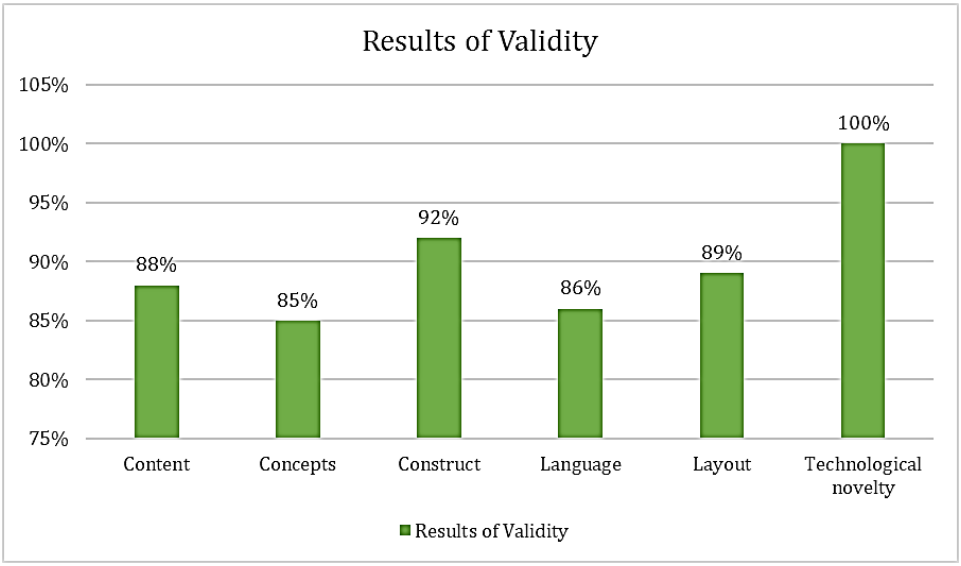

Figure 9. Results of validity score

Across the six evaluated categories, there are content validity, concept validity, construct validity, language validity, layout validity, and technological novelty validity. Augmented – Virtual Reality as learning media achieved high levels of validity. The scores reveal that it not only meets the expected standards for reliability but also effectively reflects the theory in science, ensuring its appropriateness for the intended research objectives. This comprehensive assessment underscores the media's strength in capturing relevant constructs with precision in science classrooms.

Other validations are validity of observers' questionnaire, students' response questionnaire and students' tests. Validity of these instruments is based on four categories namely content validity, concepts validity, integrated technology validity and language validity. These validations are also filled by three expert validators, and the results of validity is presented by Table 4 below

Table 4. Validity recapitulation score of instruments

Instruments	Content	Science Concepts	Integration Technology	Language	Average
Observers' Questionnaire	93%	83%	97%	93%	91.5%
Students' Response Questionnaire	92%	93%	100%	93%	94.5%
Students' Tests	91%	91%	100%	93%	93.75%
Average	92%	89%	99%	93%	93.25%

The validity of the research results regarding the development of Augmented-Virtual Reality as learning media to improve junior high school students' understanding of human digestive system material. Augmented-Virtual Reality as learning media is a product that has been developed through development research using the ADDIE development model. This development product was validated by three expert validators. Components of learning media that are validated by validators include content validity, concept validity, construct validity, language validity, layout validity, and technological

novelty validity. This media is developed by going through the validation stage to ensure that the learning media has a valid category and is suitable for application in science classrooms and used by students. The validity score was analyzed based on six main categories: content validity, concept validity, construction validity, language validity, layout validity, and technological novelty validity. Each category achieved a score in an acceptable range to excellent, with the validity of the construction and the novelty of the technology standing out as very strong. Overall the validity score was 90% in the very valid category. The results of validation by the three expert validators obtained the results of the validation of the products developed included in the very valid category. The results of the product validation assessment by the three validators in Figure 5 obtained all of aspect validated in very valid category, it can be concluded that each aspect of the product is included in the very valid category and can be used in learning activities because the product has met the eligibility requirements in terms of each aspect. Research by Nieven (1999) explains that a product produced by the development process is said to be usable if the product is relevant, contains content validity and construct validity. This opinion is also supported by Mardhiyyah et al (2022) who say that the validity of the construct aspect of the developed product includes the components of the product that are arranged in order and interconnected, while the validity in the content aspect includes the needs of the product and contains what is to be measured in the learning process. The opinion of Widjayanti et al (2018) states that a product developed will be said to be valid if it has a percentage with a valid category based on the appropriate aspects available by each validator.

Implementation

After developing the media, this media is implemented in junior high school students with a total of 40 students. While learning media are implemented in the classroom, there are observers to observe and analyze the practicality of the learning media. This observation used a questionnaire used by observers with a Likert scale of 1-5. Observation employed in eight meetings during learning with Augmented-Virtual Reality in the classroom. The results of the practicality recapitulation score of each meeting are presented in Table 5 below.

Table 5. Results of practicality recapitulation score

Observers	M1	M2	M3	M4	M5	M6	M7	M8
O1	100%	100%	100%	90%	90%	100%	100%	100%
O2	100%	100%	100%	100%	100%	100%	90%	90%
O3	90%	100%	100%	100%	90%	100%	100%	100%
Average	93%	100%	100%	93%	87%	100%	93%	93%

After developing the media, this media is implemented in junior high school students with a total of 40 students. While learning media are implemented in the classroom, there are observers to observe and analyze the practicality of the learning media. Based on Table 5 above, the mean scores obtained during the eight classroom meetings reflect varying levels of student engagement and comprehension of the science material, as influenced by the use of learning media. The scores, recorded as 93%, 100%,

100%, 93%, 87%, 100%, 93%, and 93% and all of those scores in very good criteria, respectively, indicate generally high levels of performance, with perfect scores achieved in the second, third, and sixth meetings suggesting that the students felt significantly supported by the learning media, enabling them to better understand the science concepts. Conversely, the slightly lower scores, particularly the 87% recorded in the fifth meeting, indicate that students found the learning media more challenging to use during that session, potentially impacting their ability to grasp the material fully. This pattern suggests that when the learning media are effectively aligned with the student's needs and the complexity of the material, they enhance understanding and foster improved outcomes, as evidenced by the higher scores in the majority of the meetings.

Evaluate

After learning media have been implemented in the classroom, tests obtained to measure students' understanding and evaluate learning media. Pretest and posttest and students' responses questionnaire used in this research. Students' tests will be analyzed using a paired sample t test and N-gain score to measure effectiveness of learning media, and students' responses questionnaire used to gain students feedback after using learning media in the classroom. Results of paired sample t test with Jamovi software presented in Table 6 below.

Table 6. Results of paired sample t-test

Paired Samples T-Test

								95% Confidence Interval			
			statistic	df	p	Mean difference	SE difference	Lower	Upper		Effect Size
Pretest	Posttest	Student's t	−6.99	39.0	< .001	−27.5	3.93	−35.5	−19.5	Cohen's d	−1.11

Note. H_a $\mu_{Measure\ 1 - Measure\ 2} \neq 0$

Based on table 6 it is shown that the students' score tests showed significant improvement, as reflected in the increase from a mean pretest score of 56 to a post-test score of 84, indicating a substantial enhancement in their understanding of the material. Furthermore, N-gain score is used to measure the increase of students score based on each indicators which are (1) Analysis; (2) Evaluate; and (3) Create, these results are presented on Figure 10.

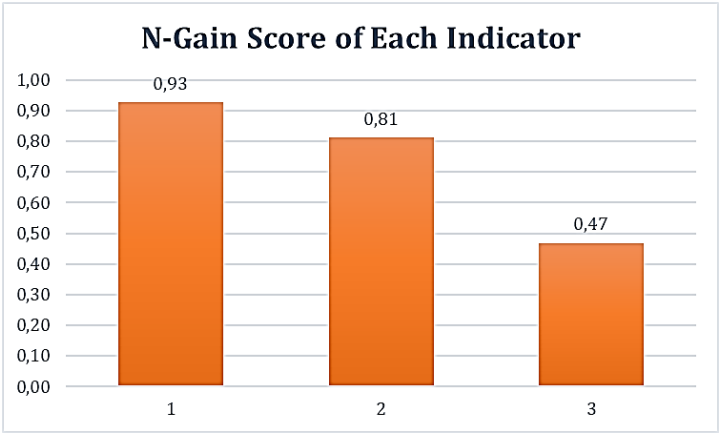

Figure 10. N-gain Score of each indicators

The last analysis of this research is students' responses through questionnaires. These questionnaires about students' feedback used Augmented-Virtual Reality as learning media in the classroom. The results of students' responses are presented in Figure 11 below.

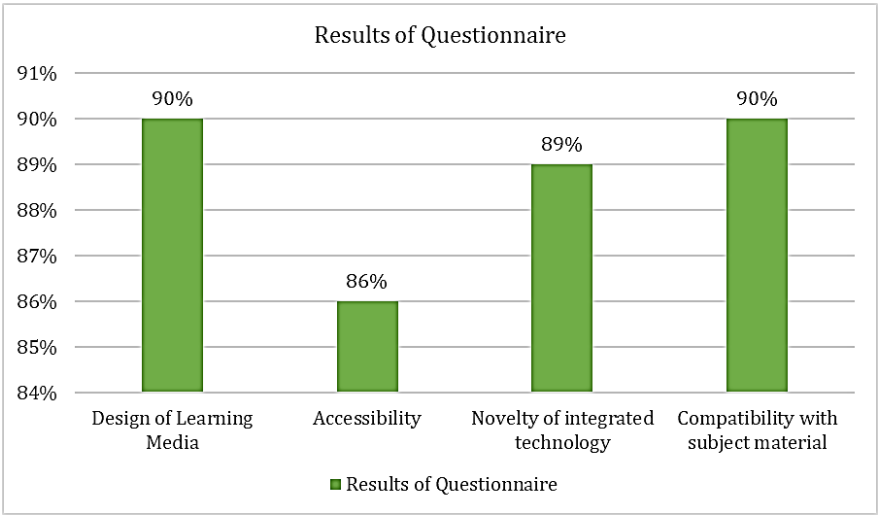

Figure 11. Results of students' response

Effectiveness of learning media measured by students test and students' responses questionnaire. Based on figure 10, the N-gain score obtained from the learning results shows the extent of the improvement in student understanding after the application of AR-VR-based learning media. The N-gain value is used to measure the effectiveness of instruction in improving mastery of the material by students. Based on the results obtained, there are variations in the N-gain score in three aspects measured, namely analysis, evaluation, and creation.

In Aspect 1 (Analysis), an N-gain score of 0.93 was obtained, which shows a very good improvement. This score is in the high category, indicating that students have made significant progress in their ability to analyze the material being taught. This shows that the learning media used is very effective in helping students understand and analyze concepts related to the human digestive system. In Aspect 2 (Evaluation), the N-gain score obtained was 0.81, which also showed a significant improvement, although slightly lower compared to the analysis aspect. This score indicates that students are able to evaluate the information they are learning quite well, although there is room for further improvement in this aspect. Overall, this score is still classified as high, indicating the effectiveness of instruction in improving student evaluation skills. However, in Aspect 3 (Creation), the N-gain score obtained is 0.47, which is included in the medium category. While there has been a recorded improvement, this score indicates that there is a greater challenge in encouraging students to apply their knowledge in the form of creations or innovations related to the material studied. This shows that although AR-VR learning media is effective in improving basic understanding and evaluation, further development is still needed so that students can be more creative in using their knowledge.

Overall, with an average N-gain value of 0.62 which is in the medium category, learning using AR-VR media shows good progress, but still has the potential to be further

developed in order to be more optimal in encouraging the development of student skills, especially in the creative aspect. The paired sample test also supports this conclusion, by showing a significant relationship between students' pretest and post-test scores, which further strengthens the effectiveness of the instructional approach applied.

Based on Figure 11, students' responses to questionnaires that measured the four main aspects of the learning experience showed very positive results, with scores of 90%, 86%, 89%, and 90% in each aspect. This score is in the very good category, which shows a positive acceptance of the learning approach and the media used. These results indicate that students find the learning process engaging and effective, with consistent scores across all aspects indicating their overall satisfaction as well as the positive impact of this method on their understanding and engagement with the material. Thus, this AR-VR-based learning media has proven to be effective in learning.

In accordance with the opinion expressed by Dwiana et al. (2022) which states that learning by using fun and interesting media makes it easier for students to understand the material so that it can improve students' learning creativity skills. The results of improving students' creativity skills supported by interesting media are in accordance with the opinion of Mustaqim and Kurniawan (2017) that the use of Augmented Reality technology as one of the learning media can make the learning process interesting and more innovative.

Augmented-Virtual Reality media can turn students to understand the material – material that seems still abstract. The 3D form of the material will help students process and understand the material taught so that students are no longer confused to learn material that is still fairly abstract. In the Assemblr edu application and MilleaLab application, in Assemblr edu there is a class feature that can make it easier for educators to share material with students. While MilleaLab application also provides convenience for teachers and students. Teachers can create VR-based learning materials using the assets provided without the need for coding and free of charge. On the other hand, students can obtain increased learning outcomes interestingly and interactively (Alkahfi et al., 2024). With the many features that can be used from Assemblr edu applications and MilleaLab applications in learning, this can make assmblr edu application and MilleaLab application as an Augmented-Virtual Reality based learning medium. The creation of Augmented-Virtual Reality on assmblr edu and MilleaLab application also seems simple so that it can be easy for developers to create the desired material.

▪ CONCLUSION

The overall result of the research shows a significant positive impact of the learning media and instructional approach on student understanding. The mean scores across eight classroom meetings, ranging from 87% to 100%, indicate that students generally felt supported by the Augmented-Virtual Reality as learning media, with higher scores reflecting an improved understanding of the science material. The test results further substantiate this improvement, as the average pretest score of 56 increased to a posttest score of 84, with an N-gain score of 0.62 categorized as moderate, showing substantial learning gains. Additionally, the questionnaire responses across four assessed aspects, highlight students' positive reception of the media and its effectiveness in enhancing their learning experience. Together, these results underscore the effectiveness of the

implemented strategies in fostering better comprehension, engagement, and satisfaction among students.

The results showed that the development process of Augmented-Virtual Reality learning media assisted with Assemblr edu applications and MilleaLab application is relatively easy to do. The results of the research can also be said to be interesting and interactive to be used as a medium of learning later. However, the development of this media is also not limited to science material only. Thus the development of Augmented-Virtual Reality learning media assisted with Assemblr edu application and MilleaLab application can be studied by further researchers to develop different materials that suit the needs of each researcher later.

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