*Inovasi Kurikulum* - p-ISSN 1829-6750 & e-ISSN 2798-1363
Volume 22 No 3 (2025) 1757-1770

**Inovasi Kurikulum**
https://ejournal-hipkin.or.id/index.php/jik

# Augmented reality media Assemblr Edu in Biology learning of the excretory system to increase student learning interest

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**ABSTRACT**
This study aims to develop and implement Augmented Reality (AR)-based learning media using the Assemblr Edu application in the context of Biology learning, especially on the excretory system material. The method used is Research and Development (RnD) with a 4D development model, which consists of four stages: Define, Design, Develop, and Disseminate. In the Define stage, needs analysis is conducted through interviews with teachers and questionnaires to students to identify challenges in learning. The Design stage includes making storyboards and developing interactive 3D organ excretory models. In the Develop stage, AR media is validated by material and media experts, and tested in class XI F1F, consisting of 36 students. The validation results show that the AR Assemblr Edu media achieved a score of 95.29 precent, which is considered "Very Valid". Teacher responses to the media reached 96.25 precent, and student responses showed a score of 95,63 precent, which is included in the "Very Practical" category. The student learning interest survey showed a score of 94.44 precent (4.78), which is included in the "Very High" category. These findings indicate that the AR Assemblr Edu media is not only effective in increasing students' interest and understanding of the excretory system but also provides an interactive and enjoyable learning experience. This study recommends the application of AR media in other Biology learning materials to increase student learning interest, especially in dealing with complex and abstract material.

**ARTICLE INFO**
***Article History:***
*Received: 7 Apr 2025*
*Revised: 25 Jul 2025*
*Accepted: 27 Jul 2025*
*Available online: 14 Aug 2025*
*Publish: 29 Aug 2025*

***Keywords:***
*Assemblr Edu; Augmented Reality: excretory system; learning interest*

**Open access**
Inovasi Kurikulum is a peer-reviewed open-access journal.

***ABSTRAK***
*Penelitian ini bertujuan untuk mengembangkan dan mengevaluasi media pembelajaran berbasis Augmented Reality (AR) menggunakan aplikasi Assemblr Edu dalam konteks pembelajaran Biologi, khususnya pada materi sistem ekskresi. Metode yang digunakan adalah Research and Development (RnD) dengan model pengembangan 4D, yang terdiri dari empat tahap: Define, Design, Develop, dan Disseminate. Pada tahap define, analisis kebutuhan dilakukan melalui wawancara dengan guru dan kuesioner kepada peserta didik untuk mengidentifikasi tantangan dalam pembelajaran. Tahap Design meliputi pembuatan storyboard dan pengembangan model 3D organ ekskresi yang interaktif. Pada tahap develop, media AR divalidasi oleh ahli materi dan media, serta diuji coba di kelas XI F1F yang terdiri dari 36 peserta didik. Hasil validasi menunjukkan bahwa media AR Assemblr Edu mencapai skor 95,29 persen, yang dikategorikan sebagai "Sangat Valid". Respons guru terhadap media mencapai 96,25 persen, dan respon peserta didik menunjukkan nilai 95,63 persen, yang termasuk dalam kategori "Sangat Praktis". Survei minat belajar peserta didik menunjukkan nilaim 94,44 persen (4,78) yang termasuk dalam kategori "Sangat Tinggi". Temuan ini mengindikasikan bahwa media AR Assemblr Edu tidak hanya efektif dalam meningkatkan minat dan pemahaman peserta didik terhadap materi sistem ekskresi, tetapi juga memberikan pengalaman belajar yang interaktif dan menyenangkan. Penelitian ini merekomendasikan penerapan media AR dalam pembelajaran materi Biologi yang lainnya untuk meningkatkan minat belajar peserta didik dalam pembelajaran, terutama dalam mengatasi materi yang bersifat kompleks dan abstrak.*

***Kata kunci**: Assemblr Edu; Augmented Reality; minat belajar; sistem ekskresi*

**How to cite (APA 7)**
Samosir, A. R., & Manalu, K. (2025). Augmented reality media Assemblr Edu in Biology learning of the excretory system to increase student learning interest. *Inovasi Kurikulum, 22*(3), 1757-1770.

**Peer review**
This article has been peer-reviewed through the journal's standard double-blind peer review, where both the reviewers and authors are anonymised during review.





hpspresents://doi.org/10.64014/jik.v22i3.120

## INTRODUCTION

The development of technology in Indonesia reflects significant and rapid progress across various aspects of life. Technology has become an essential necessity for individuals, as it contributes to addressing societal challenges faced by both professionals and the general public, particularly in fostering interpersonal relationships across multiple domains of human life (Santoso et al., 2020). The influence of technological advancement in the era of globalization cannot be overlooked, particularly in education. One unavoidable aspect is the impact of technology on educational practices, where educators are required to adapt to and utilize technological tools in the teaching and learning process, such as computers, educational applications, the internet, online learning platforms, and various other digital tools to enhance the effectiveness of instruction (Pradana, 2023).

The learning process is a sequence of activities that arise from interactions within the learning environment. It can be conceptualized as a form of communication involving three main components: the teacher as the provider of information (instructional content), the students as the recipients of information, and the information itself as the content of the communication. To enhance the effectiveness of delivering instructional material, supportive tools are required to facilitate interaction between teachers and students, commonly referred to as learning media (Mukarromah & Andriana, 2022).

Learning media are essential to instructional strategies, as they enhance educational quality and increase students' interest in learning. Learning media contribute significantly to capturing students' attention, enhancing active participation, and fostering learning enthusiasm. The use of visual and interactive media has been shown to assist teachers in delivering complex material more clearly and engagingly (Rosyiddin et al., 2021; Sugiarti et al., 2023). The implementation of digital learning media in teaching and learning activities can positively affect students' interest in learning. Digital media, such as Augmented Reality (AR), interactive videos, and 3D simulations, can present learning content in a visual, interactive, and contextualized manner, making the learning process more engaging and enjoyable. Multimedia-based information presentation can stimulate students' attention, cultivate curiosity, and motivate them to actively participate in the learning process (Sari & Prasetyo, 2024).

In biology education, Augmented Reality (AR) can be used as a medium for teaching biological content. One of the biological systems within an organism is the excretory system. This topic is difficult for students to understand because it is often taught using conventional methods that rely on two-dimensional images. Such images do not necessarily enable students to comprehend the material being presented fully (Aprilinda et al., 2020). AR offers various advantages in the learning process, particularly in enhancing students' interest, understanding, and engagement. AR can visualize abstract concepts in more concrete forms through interactive three-dimensional objects accessible via students' mobile devices, such as smartphones or tablets. This enables learning to become more contextual, flexible, and self-directed, while also supporting the principles of lifelong learning that are aligned with the demands of 21st-century education (Rahmawati et al., 2023).

Students' interest in learning is an important factor that can influence their success in the learning process. This interest may arise from prior experiences, personal characteristics, and the influence of cultural and social environments—students' interest functions as a driving force for achieving success in education. When learning is designed in an enjoyable manner, students tend to participate attentively, allowing them to process and understand the material more easily. Conversely, when students feel uninterested, bored, or even pressured during the learning process, the learning outcomes achieved tend to be less satisfactory (Budiasningrum et al., 2025).

The constraints faced by teachers in designing and utilizing instructional media, which often result in



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monotonous learning processes, represent a significant challenge. Therefore, the use of biology learning media through the Assemblr Edu application, which is specifically designed for educational purposes, can serve as an effective solution. One of its main advantages lies in its ability to visualize abstract concepts into more concrete three-dimensional forms, such as organ structures, the excretory system, or physiological processes that are difficult to explain verbally or through static images. The Assemblr Edu application can support students in understanding learning materials more effectively. Previous studies have shown that learning media based on Assemblr Edu can be utilized not only in school settings but also anytime and anywhere, thereby providing greater flexibility in the learning process (Nugrohadi & Anwar, 2022).

Assemblr Edu is considered an efficient alternative learning medium for improving the quality of the learning process and students' academic achievement. Previous studies indicate that Assemblr Edu can be utilized as an instructional medium to enhance the quality of learning processes and learning outcomes, as well as to increase students' learning motivation (Maulana et al., 2024). However, prior research has generally focused more on learning outcomes than on students' learning interests. In addition, there is limited research on AR-based learning media developed using Assemblr Edu for the human excretory system in Biology for Grade XI senior high school (SMA/MA) students. Therefore, this study makes a significant distinction from previous research by emphasizing the development of AR-based learning media using Assemblr Edu, specifically for excretory system material, to enhance students' interest in learning.

Based on initial observations conducted on February 19, 2025, at a senior high school in Medan, it was found that the learning methods employed remained conventional. In the learning process, instructional resources included textbooks, PowerPoint presentations, and YouTube educational videos, while the teaching approach employed lectures, group discussions, and student presentations. This approach led students to feel bored and disengaged during the learning process. The limited variety of instructional media also negatively affected the interest and learning outcomes of Grade XI F1F students at the Medan high school. Therefore, this study aims to develop and evaluate the effectiveness of AR-based Assemblr Edu media in Biology learning, specifically on the Excretory System topic, to enhance students' learning interest. The use of AR Assemblr Edu–based media is expected to provide a more engaging, interactive, and innovative learning experience, increase student participation, and offer a more effective and enjoyable learning process.

## LITERATURE REVIEW

### Augmented Reality (AR) in Learning

Augmented Reality (AR) is a type of media that can present objects directly within a three-dimensional (3D) visual environment. Three-dimensional media have the ability to create a unique experience by displaying the structure and mechanisms of objects comprehensively, as and by providing clear illustrations of the excretory system. AR represents an innovation that integrates the real world with virtual elements in real time through digital devices such as smartphones, tablets, and AR glasses. This technology enables users to view the real world enhanced with various digital elements, such as images, sounds, animations, or 3D models, thereby creating a more interactive and immersive experience (Permana, 2024). Although AR applications are frequently used in game development, their implementation in education remains limited in Indonesia. AR is inherently interactive because it facilitates direct interaction between students and learning materials, making the learning experience enjoyable, engaging, and more actively involved (Indahsari & Sumirat, 2023).


https://doi.org/10.64014/jik.v22i3.120

The rapid advancement of technology has increasingly encouraged its use in various daily activities, including learning. The presence of AR demonstrates its potential to develop a more innovative educational system (Al-Ansi et al., 2023). AR provides an immersive experience by using smartphones and other devices to enhance students' learning (Dhar et al., 2021). This experience helps students gain a better understanding of the material delivered by the teacher, particularly for topics that require simulation, thereby ensuring that learning objectives are achieved (Legiawan & Agustina, 2021). AR is employed as a medium during the learning process, serving as an intermediary to present material that may be abstract but is essential for students to comprehend.

### Assemblr Edu as a Learning Media

Assemblr Edu, an AR-based platform, offers numerous advantages for the learning process, particularly in biology. It greatly aids students' understanding of complex material. Furthermore, the visually appealing interface and interactive learning experience provided by this media can enhance students' interest and active engagement in the learning process. With easy access through personal devices such as smartphones and tablets, this media also allows students to learn flexibly and independently outside the classroom (Ramadan & Cahyaningsih, 2025; Hamidah et al., 2024).

The use of Assemblr Edu has also been shown to enhance memory retention and concept recall, as students not only observe but also directly interact with digital learning objects. Another advantage of this media is its ease of use. The Assemblr Edu application features a simple interface and does not require advanced technical skills, allowing both teachers and students to use it without significant difficulty. Overall, Assemblr Edu serves as an innovative learning media solution that is not only visually appealing but also provides an effective, interactive, and modern approach to teaching (Sadam et al., 2025; Kasan & Suratmi, 2025).

## METHODS

This study employs a Research and Development (R&D) approach using the 4D development model. The 4D model consists of four stages: Define, Design, Develop, and Disseminate, as outlined by Thiagarajan et al. in their book *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. This method was chosen for its effectiveness in creating products that are valid and tailored to learning needs. The product developed in this study is an Augmented Reality (AR) learning media using Assemblr Edu for eleventh-grade senior high school students, specifically for teaching Biology on the topic of the Excretory System.

In the Define stage, a needs and curriculum analysis, along with a literature review, was conducted to identify learning problems and determine the direction for media development. Data were collected through interviews with Biology teachers and questionnaires distributed to students to understand learning obstacles and the potential utilization of AR. The Design stage involved creating a storyboard, developing 3D models of excretory organs, and designing interactive features and navigation for the AR media. During this process, factors such as readability of information, ease of use, and visual appeal for students were carefully considered. Next, in the Develop stage, the AR Assemblr Edu media design was validated by content experts and media specialists to ensure the appropriateness of the content and the technology employed. A limited trial was conducted in class XI F1F, consisting of 36 students, to assess the effectiveness of the media in enhancing students' learning interest. Research data were collected through questionnaires evaluating students' interest and their responses to the use of AR media. Trials were also conducted with the Biology teacher regarding the use of AR Assemblr Edu to enable broader



https://doi.org/10.64014/jik.v22i3.120

implementation in technology-based Biology learning. However, due to various considerations, this study was conducted only up to the development stage.

The data analysis employed a scaled method with adjustments to the Likert scale. Respondents were asked to evaluate statements regarding the developed media. Validation was conducted by media experts and content specialists using instruments assessing design, functionality, and interactivity. A practical analysis was conducted to assess teachers' and students' responses to the AR Assemblr Edu media. Teacher responses were evaluated based on the suitability of the content, visual appearance, alignment with the curriculum, and the students' interest and motivation. For students, the practicality analysis consisted of 14 statements. Effectiveness analysis was conducted to measure students' learning interest through five indicators: enjoyment, curiosity, engagement, learning enthusiasm, and concentration. Through this approach, the study aimed to produce a learning media that is not only valid and practical but also effective in enhancing students' interest and understanding of the topic being taught.

## RESULTS AND DISCUSSION

This study aims to develop an Augmented Reality (AR)-based learning media using the Assemblr Edu application for Biology learning, specifically on the topic of the excretory system, and to evaluate the validity, practicality, and effectiveness of the media in enhancing the learning interest of 11th-grade high school students. The research was conducted in class XI F1F at a high school in Medan City.

### Media Validation

The validation process of the AR Assemblr Edu learning media was carried out to ensure that the developed media is not only technologically innovative but also accurate in content and aligned with instructional principles. In the initial validation conducted by media experts, the learning media achieved a score of 56.25%, categorized as "Moderately Valid". This result indicates that the media has potential but also highlights the need for significant improvements. A more detailed summary of the validation results can be seen in **Table 1** below.

**Table 1**. Hasil Validasi Media Assemblr Edu Pertama

| Aspect | Score Obtained | Maximum Score | Percentage | Criteria |
|---|---|---|---|---|
| Design | 17 | 30 | 56,67% | Moderately Valid |
| Functionality | 13 | 25 | 52% | Moderately Valid |
| Interactivity and Navigation | 15 | 25 | 60% | Moderately Valid |
| **Total** | **45** | **80** | **56,25%** | **Moderately Valid** |

*Source: Research 2025*

After revision, in response to the feedback, the researcher carried out comprehensive improvements on the media. Following the revisions, re-validation showed a significant increase in the score, reaching 95%. This score categorizes the media as "Highly Valid" in terms of technical and design aspects based on the established criteria. The results of the post-revision validation can be seen in **Table 2** below.


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**Table 2**. Second Media Validation Results After Revision

| Aspek | Skor Yang Diperoleh | Skor Maksimum | Persentase | Kriteria |
|---|---|---|---|---|
| Design | 29 | 30 | 96,67% | Highly Valid |
| Functionality | 24 | 25 | 96% | Highly Valid |
| Interactivity and Navigation | 23 | 25 | 92% | Highly Valid |
| **Total** | **76** | **80** | **95%** | **Highly Valid** |

*Source: Research 2025*

### Content Expert Validation

The validation results conducted by the content expert showed a very high score of 95.29%, which is also categorized as “Highly Valid.” This assessment provides strong assurance regarding the quality of the Biology content presented. The detailed validation results can be seen in **Table 3** below.

**Table 3**. Content Validation Results

| Aspect | Score Obtained | Maximum Score | Percentage | Criteria |
|---|---|---|---|---|
| Alignment with Curriculum | 20 | 20 | 100% | Highly Valid |
| Accuracy of Content | 18 | 20 | 90% | Highly Valid |
| Content Presentation | 28 | 30 | 93,33% | Highly Valid |
| Visualization and Media Support | 15 | 15 | 100% | Highly Valid |
| **Total** | **81** | **85** | **95,29%** | **Highly Valid** |

*Source: Research 2025*

### Teacher and Student Responses

The teacher’s response to the media reached **95.25%**, which falls into the **“Very Practical”** category. The media is considered an effective solution for addressing challenges in teaching the excretory system material.

**Table 4**. Respons guru terhadap media Assemblr Edu

| Aspek | Score Obtainde | Maximum Score | Percentage | Criteria |
|---|---|---|---|---|
| Content Relevance | 14 | 15 | 93,33% | Highly Valid |
| Visual Appearance and Media Design | 19 | 20 | 95% | Highly Valid |
| Curriculum Alignment | 14 | 15 | 93,33% | Highly Valid |
| Student Interest and Motivation | 15 | 15 | 100% | Highly Valid |
| Feasibility of AR Implementation in Schools | 15 | 15 | 100% | Highly Valid |
| **Total** | **77** | **80** | **95,25%** | **Highly Valid** |

*Source: Research 2025*

Students’ responses to the media showed a score of 95.63%, which falls into the “Very Practical” category. Students felt that this media was easy to use, engaging, and helped improve their



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understanding of the material. **Table 5** presents the students' responses to the Assemblr Edu media.

**Table 5**. Students' Responses to the Assemblr Edu Media

| Aspek | Score Obtained | Maximum Score | Percentage | Criteria |
|---|---|---|---|---|
| Student's Responses | 2410 | 2520 | 95,63% | Sangat Valid |

*Source : Research 2025*

### Students' Learning Interest

The survey on students' learning interest showed a score of 94.44%, which falls into the "Very High" category. These results indicate that the AR Assemblr Edu media effectively captured students' attention, enhanced their curiosity, and motivated them to engage more deeply in learning. **Table 6** presents the results of the students' learning interest assessment.

**Table 6**. Hasil Minat Belajar Peserta Didik

| Aspect | Score Obtained | Maximum Score | Percentage | Criteria |
|---|---|---|---|---|
| Feeling of Enjoyment | 515 | 540 | 95,37% (4,81) | Very High |
| Interest | 690 | 720 | 95,83% (4,83) | Very High |
| Engagement | 500 | 540 | 92,59% (4,70) | Very High |
| Learning Enthusiasm | 695 | 720 | 96,53% (4,86) | Very High |
| High Concentration | 490 | 540 | 90,74% (4,63) | Very High |
| **Total** | **2890** | **3060** | **94,44%.(4,72)** | **Very High** |

*Source: Research 2025*

### Discussion

The validation process is an important step to ensure that the learning media created is not only new in terms of technology, but also accurate in content and in accordance with teaching principles. This process includes evaluations conducted by experts in the relevant fields.

Validation by Media Experts, change from Quite Valid to Very Valid. In the initial validation by media experts, this learning media obtained a score of 56.25%, which based on the Likert scale is classified as "Quite Valid" (Putra & Fitrihidajati, 2022). This result indicates potential, but also emphasizes the need for significant improvements immediately. Media experts provided constructive and very detailed suggestions, which include:

1. Visual Design Aspect: Recommendations for improving layout, selecting a more harmonious and eye-friendly color scheme, and using typography that is easier to read.
2. Functionality Aspect: Enhancements to the response speed of interactive elements, faster loading time for 3D models, and overall application stability to prevent crashes or errors.
3. Interactivity and Navigation Aspect: Refinement of navigation paths to make them easier to understand, addition of visual feedback during interactions, and improvement of comfort in manipulating 3D objects (for example, zooming, rotating, and moving).

In response to the feedback, the researcher carried out comprehensive improvements on the media. After the revisions, re-validation showed a very significant score increase to 95.29%. This figure categorizes the media as "Highly Valid" in terms of technical and design aspects based on the criteria (Putra & Fitrihidajati, 2022). This significant improvement demonstrates the success of a flexible and


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responsive development process. The high validity rating from media experts ensures that the AR Assemblr Edu media is not only visually appealing but also functions well, is stable, and easy to use, thereby supporting the learning process optimally without technical obstacles. In other words, after significant improvements, this media now meets the feasibility standards for use in biology learning. This success is crucial because well-designed media, both in terms of appearance and functionality, will better attract students' interest and reduce technical barriers in the learning process.


***Figure 1.*** *Main Interface Display of AR Assemblr Edu Learning Media and 3D Model of the Excretory Organs*
*Source: Research, 2025*

Scientific Accuracy and Curriculum Alignment: Validation results from the content expert showed a very high score of 95.29%, which is also categorized as “Highly Valid.” This assessment provides strong assurance regarding the quality of the Biology content presented. The content expert evaluated several important aspects:

1. Alignment with Curriculum: The material on the excretory system is guaranteed to align with the Learning Outcomes and Learning Objectives outlined in the Merdeka Curriculum for senior high school (SMA/MA) level.
2. Scientific Accuracy: All factual data related to the anatomy, physiology, and mechanisms of the human excretory system have been confirmed for accuracy based on the latest scientific literature.
3. Content Delivery: The structure of the material presentation is considered organized, systematic, and easy to understand, with clear explanations for complex concepts.
4. Visualization and Media Support: The quality of 3D models, animations, and other visual elements is deemed effective in conveying concepts accurately and supporting understanding.

The high validation score for this content indicates that the AR Assemblr Edu media not only employs advanced technology but is also supported by a strong scientific foundation and excellent educational relevance. This is a very important requirement for effective learning media.



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The findings from this validation strongly reinforce the argument that the use of AR media is highly effective in Biology learning, especially for concepts that are difficult to understand visually (Bakari et al., 2025). The excretory system, which involves internal organs such as the kidneys, liver, lungs, and skin that cannot be seen directly, often becomes a concept that is hard for students to grasp. AR media overcomes this limitation by offering interactive 3D models that allow students to observe the organ structures more clearly. This provides a much more concrete and immersive learning experience compared to relying solely on static images or verbal explanations.

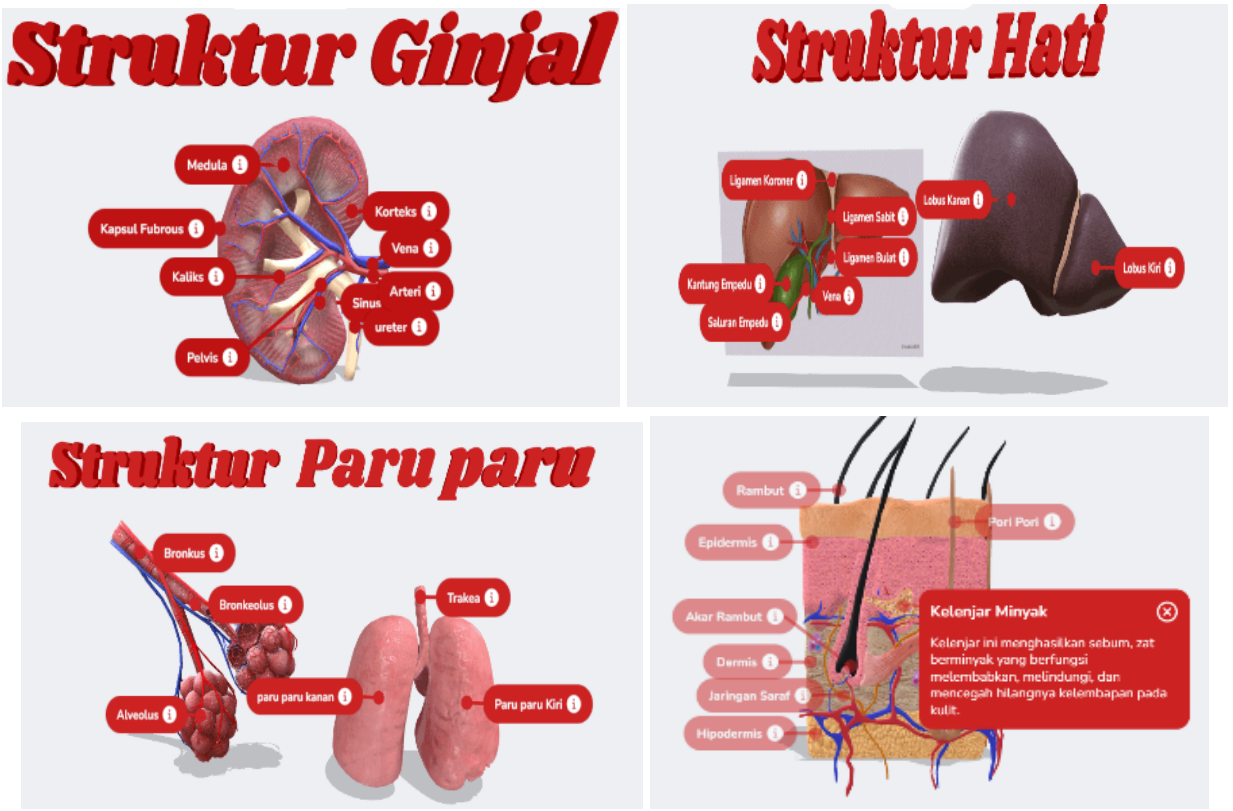


***Figure 2:*** *Example of 3D Model of the Excretory System (Kidneys/Liver/Lungs and Skin)*
*Source: Personal documentation from the researcher's learning media*

**Teacher Response**

The responses from teachers and students are an important concrete indicator of how effective the media is in actual learning situations and the extent to which it is accepted by its end users.

To Promote Active and Innovative Learning: Based on the survey results, teacher responses to the media reached 95.25%, which falls into the "Very Practical" category. This figure indicates that teachers perceive the media not merely as a teaching aid, but as a highly effective solution for addressing challenges in teaching the excretory system material. Teachers clearly conveyed that the developed media is as follows.

1. Facilitating Visualization: Material that was previously difficult to visualize using only two-dimensional images in textbooks or on the blackboard can now be presented dynamically and interactively through 3D models.
2. Promoting Active Learning: The use of AR stimulates students' curiosity, encouraging them to interact directly with the content, ask questions, and engage in discussions. This shifts the teacher's role from being merely an information provider to a learning facilitator.


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3. Aligned with the Merdeka Curriculum: This media supports the Merdeka Belajar principle, which emphasizes differentiated, exploratory, and project-based learning. Teachers feel more confident in implementing innovative teaching approaches.

The high positive response from teachers demonstrates that the AR Assemblr Edu media is not only well accepted, but also serves as a solution for enhancing teaching quality and facilitating the optimal achievement of learning objectives, including keeping up with the demands of the currently implemented curriculum, namely the Merdeka Curriculum (Ilafi et al., 2023).

**Respons Peserta Didik**

Students' feedback on the AR-based learning media showed a very impressive score of 95.63%, which falls into the "Highly Practical" category. This score reflects a very high level of acceptance and satisfaction among students regarding the use of AR Assemblr Edu in learning the excretory system material. Analysis of questionnaires and observations indicated that students felt that this media was:

1. Easy to Use: The interface design is easy to understand, and the navigation is clear, allowing students to interact smoothly without significant difficulties. Interactive features, such as easily accessible navigation buttons and clear usage instructions, help students understand how to use the media without additional assistance. This is particularly important in a learning context that emphasizes student independence. With a user-friendly interface, students can focus more on exploring the material rather than being hindered by technical difficulties.
2. Engaging: The immersive 3D visualizations, animations, and interactive elements make the learning process an enjoyable and non-monotonous experience. The AR media allows students to view the internal organs of the excretory system in real-time from various perspectives, providing a more engaging learning experience. This not only increases student interest but also creates a more dynamic and interactive learning environment.
3. Enhancing Understanding: The ability to manipulate 3D models of excretory organs enables students to strengthen and deepen their conceptual understanding. Interactive features, such as additional information labels that appear when students interact with the models, allow them to gain further explanations about the function of organs and the processes occurring within them. For example, when a student clicks on the 3D model of the liver, they can see information about the function of the organ's structures, helping them connect theory with practice. This experience not only makes learning more concrete but also helps students build a deeper and more comprehensive understanding of the material being taught.

Overall, the positive responses from students indicate that the AR Assemblr Edu media not only successfully captures their attention but also contributes to improving understanding and learning interest. This interactive and enjoyable learning experience aligns with 21st-century learning principles, which emphasize the importance of active student engagement in the learning process. Thus, the use of AR media in Biology learning, particularly on the excretory system material, appears to help create an innovative and engaging learning environment.

The AR Assemblr Edu media enables three-dimensional and interactive visualization of excretory organs, helping to bridge abstract concepts into more concrete understanding. Recent research shows that XR technologies such as AR significantly enhance anatomy comprehension compared to traditional learning methods, with more than 80% of students reporting AR as a useful learning aid (Garcia-Robles et al., 2024).

Furthermore, studies indicate that Assemblr Edu media is highly beneficial in the learning process due to



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its flexible nature. The application provides students the opportunity to learn individually or in groups, anytime and anywhere, as long as digital devices and internet access are available. This flexibility is crucial in the 21st-century learning era, which emphasizes easy access, adaptability, and lifelong learning (Blyznyuk et al., 2025). Learning media in innovative classroom processes creates learning experiences that meet the needs of students in the digital era and Society 5.0 (Nurdiyanto et al., 2024; Trikotama et al., 2024).

**Student Learning Interest**

Increasing students' interest in learning is one of the primary goals of this study, and the results indicate success. The improvement in student learning interest shows a score of 94.44%, which falls into the "Very High" category. This result clearly demonstrates that the AR Assemblr Edu media effectively captures students' attention, stimulates curiosity, and motivates them to engage more deeply in learning. A strong interest in learning is a fundamental requirement for academic success, as students with high interest tend to be more active, persistent, and intrinsically motivated to understand the material. The high scores across all indicators indicate that AR Assemblr Edu has successfully created a supportive and engaging learning environment. This also illustrates the potential of AR to enhance students' interest in the learning process (Einsthendi et al., 2024).

These findings are supported by previous research showing that the use of AR Assemblr Edu media has a significant positive impact on students' learning interest (Masri et al., 2023). That study found that students who used AR Assemblr Edu experienced a very high increase in learning interest, demonstrating that the media is effective in capturing attention, stimulating curiosity, and motivating deeper engagement in learning.

Engaging and interactive learning tools provide significant psychological effects, positively influencing students to participate more actively and enthusiastically in the learning process. In this case, the Assemblr Edu application helps students understand concepts visually, making it easier for them to grasp complex and abstract materials such as the excretory system. This AR media enables clear and engaging visualization of complex objects and concepts (Tika et al., 2024).

The impact of technological innovation and contextualized learning on students' learning interest is strongly influenced by the technological advancements applied. The learning experiences provided by AR make the learning process feel more realistic and contextually relevant, as if students are performing a "virtual dissection" or observing organs directly. As explained, AR-based learning designed according to individual needs can accommodate differences in students' learning styles and comprehension speed, providing a more equitable, interactive, and motivating learning experience (Wiliyanti, 2024).

With an interactive interface and access via students' mobile devices, AR media not only supports active student engagement in the learning process but also extends learning beyond the classroom. This aligns with 21st-century learning principles emphasizing flexibility, independence, and lifelong learning (Rahmawati et al., 2023). This demonstrates that learning is not confined to the classroom but can continue at home or other comfortable environments, thereby enhancing students' independence in learning.

In principle, AR Assemblr Edu serves as a learning medium expected to address several learning challenges as follows (Oktavianda et al., 2024; Resti et al., 2024).

1. Overcoming Boredom and Low Engagement: Through interactive and realistic 3D visualization, this


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platform transforms the learning process from passive to more active. Students are no longer just listening or reading; they can manipulate organ models, explore anatomical details, and understand physiological processes visually. This directly counters the boredom caused by traditional methods and increases active student participation.

2. Overcoming Boredom and Low Engagement: Through interactive and realistic 3D visualization, this platform transforms the learning process from passive to more active. Students are no longer just listening or reading; they can manipulate organ models, explore anatomical details, and understand physiological processes visually. This directly counters the boredom caused by traditional methods and increases active student participation.
3. Increasing Interest and Learning Motivation: The high student response of 95.63% and a significant increase in learning interest of 94.44% indicate that this media is well-received. This is due to its attractive visual design, simple usability, and a learning experience that differs from previous routines. Students become more enthusiastic and less easily bored, which in turn boosts their active participation in the learning process. These findings are supported by previous studies showing that implementing AR technology offers engaging 3D visualization and interactive experiences that enhance student understanding through immersive, interactive, and contextual visual experiences.
4. Supporting Teacher Innovation: This media provides useful and efficient tools for teachers to innovate in instruction. Educators who were previously limited to traditional methods now have the option to deliver material in a more modern and engaging way, aligned with the needs of the Merdeka Curriculum and 21st-century learning. This also helps address the lack of teacher skills in creating varied learning media, as Assemblr Edu offers a platform that is easy to operate for producing AR content.

In general, the development of the AR Assemblr Edu media has proven to be effective, valid, and easy to use for increasing students' learning interest in the excretory system material. As revealed by previous research, the digital media used, namely Assemblr Edu, can improve learning outcomes and increase student participation in mathematics lessons (Dewi et al., 2020). In addition to enhancing student participation, the Assemblr Edu application can also be utilized to create interactive learning media that provide new knowledge, interactive and collaborative learning experiences, as well as enjoyable activities (Amalia & Mawardini, 2024; Laili & Nurmawati, 2024). Furthermore, the use of Assemblr Edu learning media offers an engaging, interactive, and realistic learning experience while fostering students' creativity in organizing ideas and creating works (Masri et al., 2023). Therefore, the use of AR technology in Biology learning is very important and should be applied to other biology topics and subjects, especially for topics that are abstract and complex. This media not only increases students' interest in learning but also helps them understand concepts better and prepares them to face the digital era.

## CONCLUSION

This study successfully developed an Augmented Reality (AR) based learning media through the Assemblr Edu application, specifically designed to increase the learning interest of 11th-grade high school students in excretory system material. Using a Research and Development (R&D) approach with the 4D development model, the resulting media met the criteria for validity and practicality and proved



https://doi.org/10.64014/jik.v22i3.120

effective in creating an interactive and engaging learning experience. The applied AR technology can overcome challenges in Biology learning, particularly in explaining complex and abstract concepts. The use of interactive 3D models enables students to visually understand the structure and function of organs in the excretory system, thereby enhancing their engagement and motivation. Overall, this study demonstrates that the implementation of AR media not only increases students' learning interest but also contributes significantly to their understanding of the material. Therefore, the AR Assemblr Edu media can serve as an effective solution to improve the quality of learning, particularly in Biology education, and it is recommended that the use of AR media be expanded in other learning contexts to support the development of more innovative and responsive education in the digital era.

## AUTHOR'S NOTE

Penulis menyatakan bahwa tidak ada konflik kepentingan terkait publikasi artikel ini. Penulis menegaskan bahwa data dan isi artikel bebas dari plagiarisme.

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