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Development of Augmented Reality-Based Anatomy Learning Media (ARANOMI) for Vocational Health Students

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Abstract

This study aims to develop and implement the Augmented Reality Anatomy and Physiology (ARANOMI) application as an innovative learning medium in nursing education, specifically for understanding anatomy and physiology and promoting the practice of clean and healthy living (PHBS). The application is designed as a mobile-based platform supported by WebAR and contains content such as 3D organ models, explanations of physiological functions, and integrated PHBS education. The research employed a Research and Development (R&D) approach, consisting of stages of design, development, and implementation. The implementation results among nursing students showed a positive impact on their understanding and learning motivation. Based on the evaluation, 87% of students reported that learning became more engaging, while 82% stated they felt more motivated to study anatomy and physiology. In addition, most students actively participated in group discussions and independent exploration through the application. Student enthusiasm indicates that ARANOMI provides a more realistic, interactive, and contextual learning experience. However, several technical challenges were identified, including long loading times for 3D models on low-specification devices and dependence on a stable internet connection. This study concludes that the ARANOMI application effectively supports the anatomy and physiology learning process using augmented reality technology, enhances student engagement, and is relevant for application in nursing education. Future development prospects include optimizing the application's technical performance and expanding its use to other fields of health education.

Keywords: Anatomy and Physiology, ARANOMI, Augmented reality, Healthy Lifestyle, Nursing Education

1. INTRODUCTION

The development of information and communication technology (ICT) has brought significant changes to the world of education, including in the fields of health and nursing. The use of digital technology, particularly Augmented Reality (AR), has garnered increasing attention as an interactive learning medium that enhances the quality of education. AR enables the integration of virtual objects into real-world environments, providing a more realistic, contextual, and easy-to-understand learning experience [1]. In the context of nursing education [2], the use of this technology is considered essential for strengthening students' understanding of anatomy and physiology concepts, which serve as the foundation of nursing practice.

Anatomy and physiology is one of the fundamental courses that nursing students must master because it directly relates to clinical skills in providing nursing care. However, various studies indicate that students often experience difficulties in understanding body structures and physiological functions using conventional learning methods that rely on text or two-dimensional images [3]. These difficulties create a gap between theory and practice, thus necessitating innovative learning media that are more interactive and contextual.

Several previous studies have utilized AR in health education. For example, Study [4] showed that the use of AR can enhance students' spatial understanding and memory retention. Other research has demonstrated that AR is effective in visualizing complex anatomical structures that are difficult to explain using traditional media [5]. Meanwhile, studies also show that smartphone-based AR applications can increase learning motivation among nursing students [6]. However, most of these studies still focus solely on anatomical visualization, without linking anatomy and physiology comprehension to the development of broader health behaviors.

To address this gap, the present study developed an innovation called Augmented Reality Anatomy and Physiology (ARANOMI), an AR-based educational medium designed not only to strengthen understanding of anatomy and physiology but also to serve as a tool for health promotion by emphasizing the

importance of clean and healthy living practices. The integration of anatomy and physiology learning with health education through AR is expected to offer a more comprehensive approach to supporting nursing education in the digital era.

Several studies have shown that Augmented Reality has great potential in enhancing anatomy learning. Confirmed that AR can clarify the visualization of complex anatomical structures through interactive 3D models [7], [8] found that AR can improve concept retention and spatial understanding. [9] also demonstrated that AR can increase learning motivation in vocational students, and [10] demonstrated improved anatomical analysis skills through AR integration. However, the application of AR is still general and has not been specifically targeted to the needs of vocational health students, making the development of ARANOMI a more relevant and applicable learning medium.

Furthermore, several other studies have also confirmed the effectiveness of AR in anatomy and vocational health education. For example, research by [11] demonstrated that the use of AR in the musculoskeletal system enhanced students' understanding of the position and function of body organs. A study by [12] found that AR can reduce anatomical misconceptions through layered visualizations that allow users to see body structures in depth. Research by [13] also confirmed that AR media provides a more independent learning experience and facilitates the development of practical skills for vocational students. These findings underscore the importance of developing ARANOMI as a learning innovation that addresses the unique needs of vocational health education.

The novelty of this study lies in its integrative concept that combines the visualization of anatomy and physiology with learning about clean and healthy living behaviors. This approach differs from previous studies that tended to focus solely on the visualization of body organs. Therefore, this research is expected not only to enhance the quality of anatomy and physiology learning but also to strengthen nursing students' awareness of the importance of practicing healthy lifestyles in both clinical practice and daily life.

Based on the explanation above, the objectives of this study are: (1) to develop ARANOMI as an interactive AR-based nursing education medium; (2) to analyze the effectiveness of ARANOMI in improving students' understanding of anatomy and physiology concepts; and (3) to evaluate ARANOMI's contribution in fostering awareness of the importance of clean and healthy living practices.

2. MATERIALS AND METHOD

2.1. Material

The use of Augmented Reality in education has been widely studied and proven to enhance learning quality through interactive visualization. AR can integrate virtual objects into the real world in real time [14], thereby enriching user experiences [15]. This concept has been widely developed in health education, particularly for understanding anatomy and physiology, which involve high levels of complexity. The role of AR in education has been shown to increase student engagement and spatial understanding. AR provides significant advantages in anatomy learning because it enables students to visualize body structures in three dimensions, which are difficult to explain using traditional media [16].

In the field of nursing, [17] reported that the use of AR not only increases learning motivation but also strengthens students' memory retention of learning materials. Similar results were shown by [18], who examined an AR application for anatomy learning and found a significant improvement in the understanding of complex anatomical concepts. Another study [19] developed a smartphone-based AR application for anatomy learning and found increased learning motivation and student interaction in understanding the material. Research by [20] further emphasized that AR is effective as a nursing education medium, particularly in bridging the gap between theory and practice.

Although these studies demonstrate the effectiveness of AR in supporting the understanding of anatomy and physiology, most research remains focused on the cognitive aspects, such as improving conceptual understanding and learning motivation. Few studies integrate anatomy and physiology comprehension with health behavior education, particularly in promoting clean and healthy living practicesan essential component of nursing education.

Based on previous research, AR has been proven effective in improving the quality of anatomy and physiology learning. However, most studies stop at visualization and motivation enhancement. The novelty of this study lies in the development of ARANOMI, an educational medium designed not only to strengthen anatomy and physiology understanding but also to integrate clean and healthy living practice education. This integrative approach is expected to bridge the gap between theoretical anatomy and physiology concepts and real-world health promotion practice through digital technology.

2.2. Method

This study employed a Research and Development (R&D) approach [21] with a focus on developing an Augmented Reality–based educational medium (ARANOMI). The research methodology does not merely describe theoretical foundations but also presents the actual procedures undertaken by the researchers throughout the product development and evaluation processes. The stages followed were adapted from the

ADDIE model (see Figure 1) (Analysis, Design, Development, Implementation, Evaluation) [22], which is considered suitable for the development of educational software.

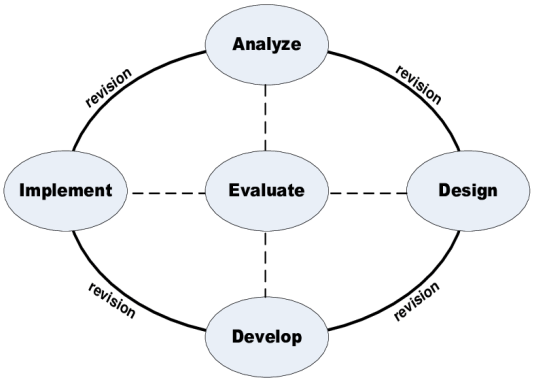

Figure 1. ADDIE

This study employed an R&D approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), adapted for the development of Augmented Reality (AR)–based educational software. The first stage was needs analysis, conducted through literature review, observation of anatomy and physiology learning activities, and interviews with nursing lecturers. This analysis aimed to identify students' difficulties in understanding body structures and functions when using conventional media alone, thereby highlighting the need for an interactive learning medium that presents three-dimensional anatomical visualization while integrating education on clean and healthy living practices.

The next stage was the design phase, which involved planning the content, including anatomy and physiology materials (such as the respiratory, digestive, cardiovascular, and renal systems), as well as relevant health education messages. This stage also involved preparing the technical design, including storyboards, user interface and user experience (UI/UX) design, and selecting the development technologies. The ARANOMI application was designed using WebAR, while the anatomical models were created using Vectary and 3D assets sourced from Sketchfab.

Next, the development stage was carried out by integrating the 3D anatomical models into WebAR, adding AR markers, and equipping the application with supporting features such as text, audio, and interactive animations. The initial product was then tested internally (alpha testing) to ensure that the application functioned properly on Android devices. Following this, the implementation stage was conducted through limited trials involving first-semester nursing students enrolled in the Anatomy and Physiology course. The students were introduced to the ARANOMI application, used it during learning activities, and then provided feedback through questionnaires regarding usability, interactivity, and the perceived learning benefits.

The final stage was evaluation, consisting of formative and summative evaluations. Formative evaluation was conducted throughout the development process by revising the product based on feedback from users and lecturers. Summative evaluation was carried out after implementation by comparing students' pre-test and post-test results to measure the improvement in their understanding of anatomy and physiology, as well as analyzing student responses regarding the effectiveness of ARANOMI as an educational medium supporting clean and healthy living practices. The results of these evaluations served as the basis for refining ARANOMI so that it can function optimally as an interactive learning medium in the field of nursing.

3. RESULTS AND DISCUSSION

The results of this study, in the form of the ARANOMI Application System Model, produced an Augmented Reality based application design intended as a nursing education medium to enhance understanding of human anatomy and physiology while also promoting the PHBS. The system was designed to be accessible via Android-based mobile devices, making it easy to use for nursing students as well as the general public.

3.1. Analysis

The analysis stage was conducted to identify nursing education needs related to clean and healthy living practices (PHBS). The results of the observation showed that nursing students still struggled to visually understand anatomy and physiology, which affected their ability to apply PHBS concepts in daily practice. The needs analysis indicated the importance of using interactive Augmented Reality technology capable of presenting three-dimensional and interactive visualizations of human organs.

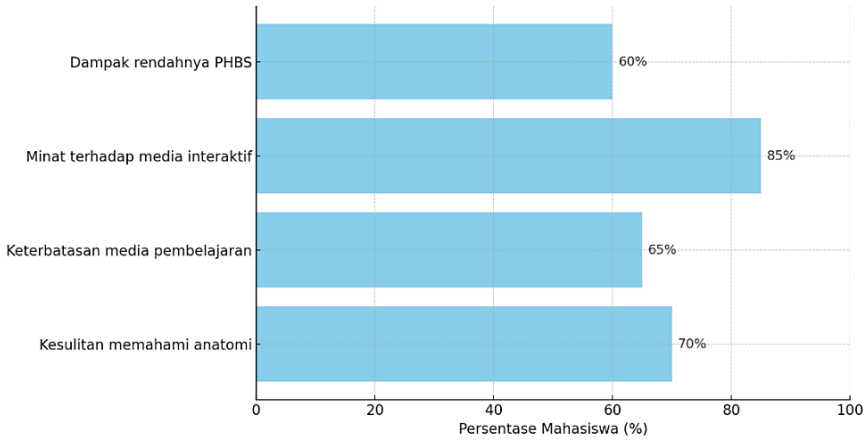

Figure 2. Results of Nursing Education Needs Analysis

Based on the results of the needs analysis in Figure 2, the following qualitative data were obtained: approximately 70% of students experienced difficulties in visually understanding anatomy and physiology, 65% considered the available learning media to be limited, 85% showed high interest in using interactive technology-based media, and 60% stated that limited understanding of anatomy affected the optimal implementation of PHBS. The graphical visualization above illustrates that the majority of students require innovative learning media, indicating that Augmented Reality technology is an appropriate solution for improving anatomy and physiology understanding while also supporting PHBS education.

3.2. Design

In the design stage, the structure of the ARANOMI application was formulated, covering anatomy and physiology content, interactive learning features, and simulations for PHBS implementation. The user interface was designed to be simple and user-friendly, integrating 3D organ models along with textual and audio information. In addition, the learning flow was organized into modular formats, making it suitable for use in both practical sessions and independent learning scenarios. In the design stage, the structure of the ARANOMI application was formulated, covering anatomy and physiology content, interactive learning features, and simulations for PHBS implementation. The user interface was designed to be simple and user-friendly, integrating 3D organ models along with textual and audio information. In addition, the learning flow was organized into modular formats, making it suitable for use in both practical sessions and independent learning scenarios. ARANOMI application design can be seen in Figure 3.

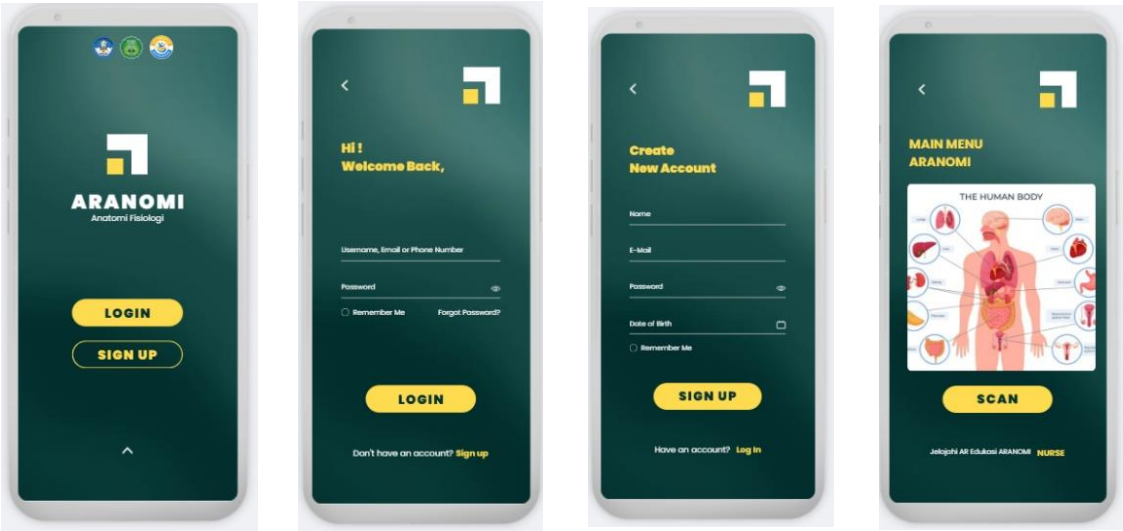

Figure 3. ARANOMI Application Design

3.3. Development

The development stage produced the ARANOMI mobile application supported by WebAR. The anatomical models were created in 3D using SketchUp and then integrated into the application. The educational content includes explanations of anatomy, organ functions, and their relevance to the

implementation of clean and healthy living practices (PHBS). Internal testing was conducted to ensure that the application runs smoothly, is interactive, and can be used across various Android devices. Development results can be seen in Table 1.

Table 1. Development Results

Component	Development Results
3D Anatomical Model	Created using SketchUp, it includes the heart, lungs, liver, kidneys, and digestive system. Exported to glTF/OBJ format and then integrated into WebAR.
Educational Content	Complete with explanations of anatomy, organ functions, and their relationship to PHBS. Information is presented in text and audio formats.
Application Interface	Simple, responsive, and user-friendly design. Main menu: Select Organ, PHBS Simulation, and Anatomy Information.
WebAR Integration	Smartphone cameras can scan markers to display 3D models. Interactive features include rotation, zoom, and organ animation.
Internal Trial	Tested on 10 different Android devices. Results: 90% smooth, interactive, and compatible on most devices. Issue: Slower loading times on low RAM.

3.4. Implementation

The ARANOMI application was implemented in nursing education, focusing on anatomy and physiology materials that are often considered challenging for students to understand. Through the use of this application, students were guided to explore human organs more deeply, understand the physiological functions of each organ, and relate them to the PHBS in daily life. The implementation process was carried out gradually through various learning activities, including laboratory practicum sessions, group discussions for shared understanding, and individual assignments that encouraged students to engage in independent exploration.

Student responses to the use of ARANOMI showed high enthusiasm, as the application provided a more realistic, contextual, and engaging learning experience compared to conventional methods. The visualization of human organs in three-dimensional form allowed students not only to see but also to interact directly with the material, making the learning process more meaningful. In addition, students' participation in discussions and independent exploration increased due to a higher sense of curiosity about the content.

The implementation results indicated that ARANOMI had a positive impact on students' understanding, particularly in linking anatomy and physiology concepts with healthy living practices. The application not only enriched the classroom learning experience but also encouraged students to be more aware of the importance of applying PHBS in their daily lives. Thus, the implementation of ARANOMI can be viewed as an innovative step in providing an interactive learning medium that aligns with the needs of nursing students in the digital era and holds significant potential for further development in other areas of health education.

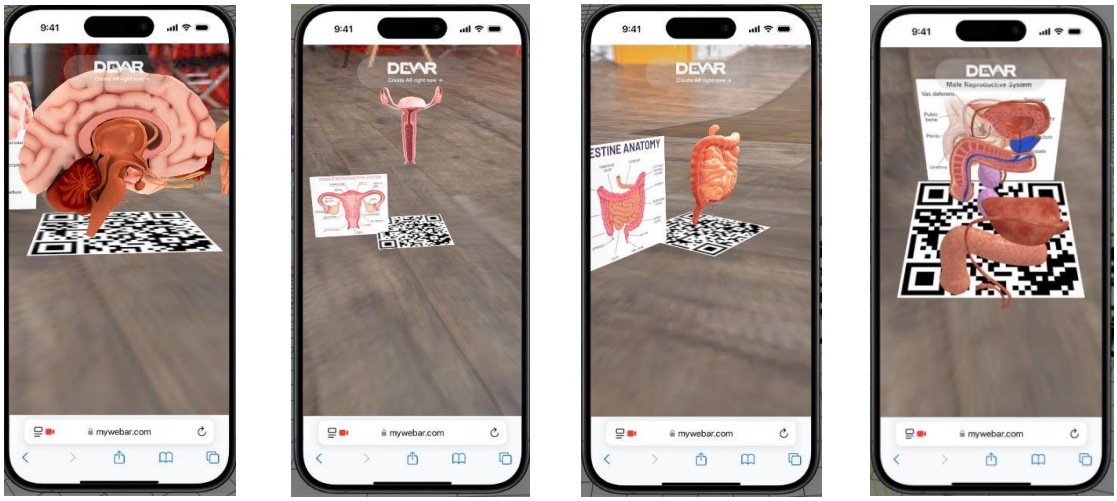

Figure 4. ARANOMI Application

In Figure 4 students utilized the ARANOMI application to explore human organs presented in interactive 3D models. The organs featured in the application include the lungs, brain, liver, kidneys, pancreas, intestines, heart, stomach, as well as the male and female reproductive systems. Each organ is not only visualized in three dimensions but also complemented with textual and audio information regarding its anatomical structure, physiological functions, and its relevance to the practice of clean and healthy living behaviors (PHBS). Through these features, students gained a more realistic, understandable, and interactive learning experience, thereby supporting a more effective anatomy and physiology learning process.

Students used the application to explore the 3D organ models, understand their physiological functions, and relate them to PHBS practices through laboratory activities, group discussions, and individual assignments. Student responses were very positive, with 87% stating that the learning process became more engaging, 82% feeling more motivated to study anatomy and physiology, and most students actively participating in discussions and independent exploration. This enthusiasm demonstrates that ARANOMI successfully provides a realistic and interactive learning experience that enhances student engagement.

In addition, the use of ARANOMI encouraged students to develop higher-order thinking skills by requiring them to analyze organ functions, compare normal and abnormal physiological conditions, and apply PHBS principles to real-life scenarios. The integration of AR into collaborative learning activities also fostered peer-to-peer interaction, as students discussed their findings, shared interpretations, and solved learning tasks together. This experiential learning approach not only increased conceptual understanding but also strengthened students' confidence in using digital learning tools. The combination of interactivity, visual immersion, and collaborative engagement underscores ARANOMI's potential to transform the learning environment into a more dynamic, student-centered, and technology-driven educational experience.

However, several technical challenges were identified, such as longer loading times for 3D models on low-spec devices and dependence on a stable internet connection. Overall, the implementation of ARANOMI can be considered successful in strengthening interactive learning processes based on augmented reality technology.

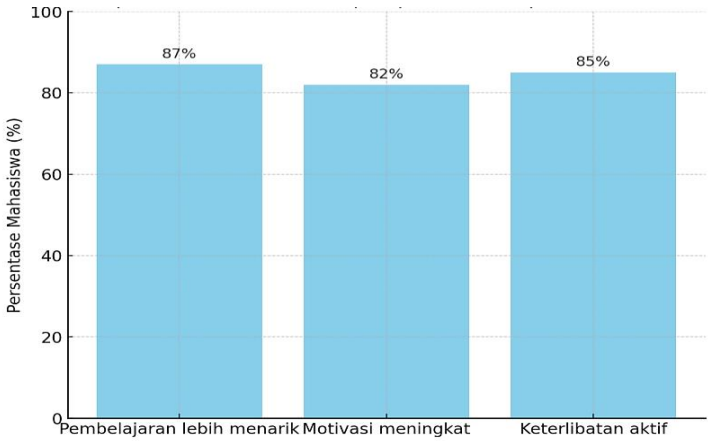

Figure 5. Student Response to the Implementation of ARANOMI

Student response to the use of ARANOMI was very positive (see Figure 5). Most students expressed high enthusiasm because the application provided a more realistic, engaging, and interactive learning experience compared to conventional methods. The implementation results also showed an increase in students' understanding of both anatomical structures and the application of PHBS in everyday life. Therefore, the implementation phase can be concluded as successful, as ARANOMI was able to support the nursing learning process more effectively and contextually. ARANOMI application development can be seen in Figure 6.

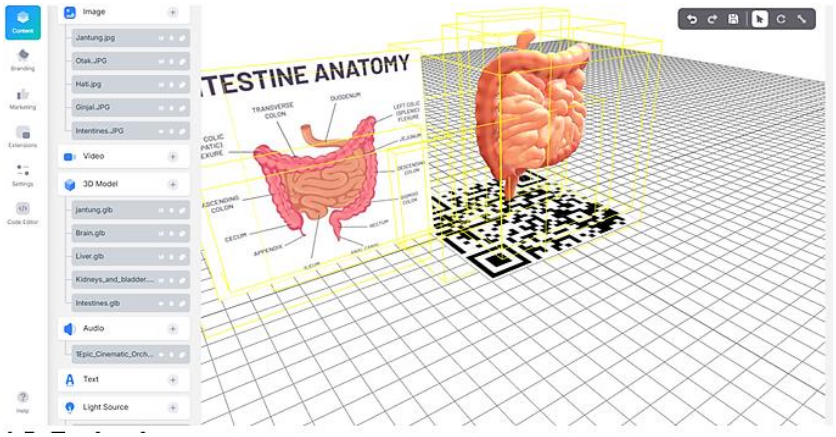

Figure 6. ARANOMI Application Development

Evaluation of the ARANOMI application was carried out using both formative and summative approaches. The formative evaluation included limited trials designed to assess ease of use, interface quality, and clarity of the learning materials. Based on the assessment results, all evaluated aspects received high scores ranging from 85% to 90%, indicating that the application falls into the highly feasible category (see Figure 7).

He ease of use aspect obtained a score of 85%, indicating that the application is easy for students to operate without requiring significant technical adjustments. The interface design aspect received a score of 88%, reflecting that the visual layout and navigation are attractive, intuitive, and supportive of user comfort. The clarity of learning materials achieved the highest score, 90%, demonstrating that the educational content including text, audio, and 3D visualizations is very clear, well-structured, and effective in enhancing students' understanding of anatomy and physiology.

Formative tests covering ease of use, interface design quality, and clarity of materials show that ARANOMI is able to provide an efficient, comfortable, and informative learning experience for students. Evaluation of the ARANOMI application conducted through formative and summative approaches shows that this learning media has a very high level of feasibility, as evidenced by consistent assessment scores. Overall, the formative evaluation results confirm that ARANOMI is a highly feasible interactive learning medium with strong potential to enhance health literacy and promote Clean and Healthy Living Behavior (CHLB) through augmented-reality-based understanding of anatomy and physiology.

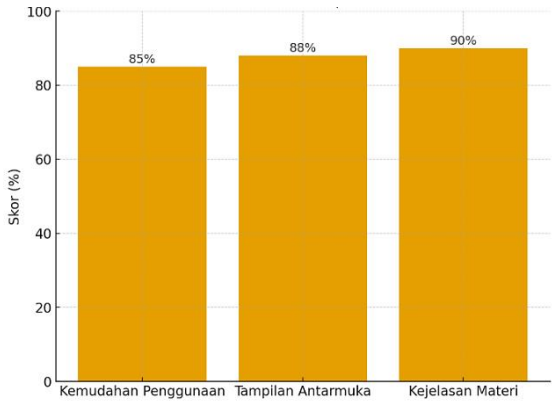

Figure 7. Results of the Formative Evaluation of the ARANOMI Application

Summative evaluation was conducted through user satisfaction questionnaires as well as pre-test and post-test assessments measuring students' understanding of anatomy, physiology, and CHLB. The results

showed a significant improvement in student comprehension, with more than 79% of respondents stating that the ARANOMI application greatly supported the interactive learning process. The summative evaluation involving 58 students demonstrated a notable increase in learning outcomes. The average pre-test score of 59.1% indicated that students' initial knowledge was still limited, highlighting the need for a learning medium that is more interactive and easier to understand. After using ARANOMI, the average post-test score increased to 79.1%, reflecting a 20-point improvement in comprehension (see Figure 8). This increase indicates that ARANOMI is effective as an augmented-reality-based educational tool, as it provides more realistic, interactive, and contextual visualizations of anatomical structures. Thus, ARANOMI not only helps students develop a deeper understanding of physiological concepts but also encourages greater awareness and implementation of CHLB practices in daily life.

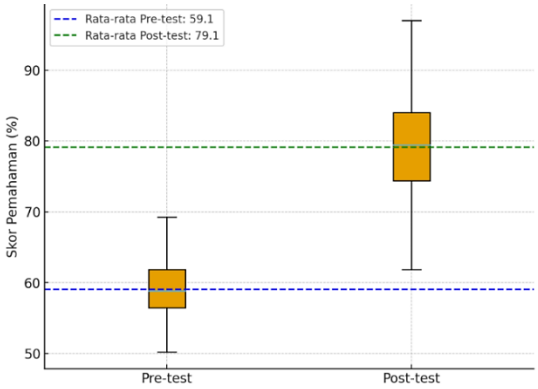

Figure 8. Results of the Summative Evaluation of the ARANOMI Application

Going forward, this research needs to develop more in-depth AR features, such as physiological animations, basic clinical case simulations, artificial intelligence integration for personalized learning, and trials with a wider sample so that the effectiveness of ARANOMI can be tested across health vocational education institutions.

3.5. Implementation

The findings of this study demonstrate that ARANOMI serves as an innovative educational medium for learning anatomy and physiology while simultaneously functioning as a tool for health promotion. The initial problem, namely the limitations of conventional, non-interactive learning media, was effectively addressed through the use of AR-based 3D visualizations that are more engaging and contextual. This aligns with previous studies, such as [22] and [23], which have confirmed that augmented reality technology enhances the understanding of abstract concepts in health-related fields. However, the novelty of this study lies in the integration of CHLB content into anatomy learning, an area that has not been widely explored in prior research.

The results further show that the ARANOMI application, developed using Augmented Reality, successfully improves nursing students' understanding of anatomy and physiology while encouraging the adoption of CHLB practices. This is evident from the significant increase in students' average comprehension scores. These findings are consistent with previous research indicating that AR positively contributes to learning outcomes in health education [24], [25]. The use of interactive 3D anatomical models allows students to explore organ structures more realistically than with conventional media. Such visualizations help overcome the limitations of text-based and two-dimensional materials, thereby supporting more comprehensive understanding of physiological concepts. Earlier studies also note that AR-based three-dimensional representations enhance knowledge retention and clinical skill development among health science students [26], [27].

In terms of system requirements, ARANOMI has fulfilled functional aspects such as the ability to display interactive anatomical objects and non-functional aspects, including ease of use, responsiveness, and high user satisfaction. This system model holds strong potential for broader implementation as both an educational tool in nursing and a preventive effort to promote healthy behavior within communities. Therefore, this study reinforces existing theories that Augmented Reality in health education not only improves cognitive learning outcomes but also supports practical skills, motivation, and authentic learning experiences [28].

Moving forward, ARANOMI has promising potential for cross-disciplinary development in medical education, physiotherapy, midwifery, and other health fields, positioning it as a valuable contribution to improving educational quality and public health awareness.

3.6. Discussion

The findings of this study indicate that the ARANOMI application, developed using Augmented Reality, provides a significant contribution to improving nursing students' understanding of anatomy and physiology as well as their application of CHLB. The improvement in test scores from 59.1% (pre-test) to 79.1% (post-test) demonstrates that AR-based learning delivers richer, more visual, and more interactive experiences compared to conventional materials such as textbooks or two-dimensional images. These findings align with previous research [29], [30], [31], which confirms that AR is effective in visualizing abstract and complex concepts in health education. ARANOMI enables students to interact directly with 3D anatomical models, overcoming limitations of traditional learning methods that are typically passive and lack contextual depth. Positive student responses 87% found the learning process more engaging, and 82% reported higher motivation, highlighting that AR technology supports greater engagement and learning motivation.

Beyond cognitive improvement, ARANOMI also enhances health awareness by integrating CHLB content. This integration represents an added value that has not been widely explored in previous AR-based research. Embedding preventive health concepts into anatomy learning helps students link structural and physiological knowledge with practical healthy living behaviors.

Nevertheless, some technical limitations were identified. Devices with lower specifications experienced longer loading times, and the application's reliance on stable internet connectivity posed challenges for continuous use. Future development may consider optimizing 3D model sizes, enabling offline AR capability, or creating a native application version to improve performance. Overall, this discussion highlights that ARANOMI successfully addresses the learning needs of the digital era by offering an interactive approach that not only enhances academic understanding but also supports the development of health-conscious behaviors. These findings open opportunities for broader implementation in other health education fields such as midwifery, physiotherapy, and medical education.

4. CONCLUSION

The conclusions of this study reaffirm that the development of ARANOMI successfully aligns with and achieves the primary objectives of the research, namely improving nursing students' understanding of anatomy and physiology while promoting CHLB. The formative evaluation demonstrated high feasibility reflected in scores of 85% for usability, 88% for interface design, and 90% for clarity of material, indicating that ARANOMI effectively functions as an interactive learning tool. Likewise, the summative evaluation revealed a substantial improvement in learning outcomes, with pre-test scores increasing from 59.1% to 79.1%, demonstrating enhanced comprehension consistent with the research goals.

Furthermore, the implementation findings showed that ARANOMI increases learning engagement (87%), boosts motivation (82%), and encourages active participation, directly addressing the research aim of creating a more interactive and student-centered learning environment. Although several limitations were identified, such as slower 3D rendering on low-specification devices and reliance on stable internet connectivity, these challenges do not diminish the overall effectiveness of the application. Instead, they offer valuable insights for improvement and future research. In conclusion, ARANOMI has met the intended research objectives, proving to be a relevant and effective innovation in nursing education with strong potential for broader application across various health-related fields.

These results emphasize that ARANOMI is an effective interactive educational tool that aligns with the demands of modern digital learning environments. Nevertheless, limitations such as device performance constraints and dependence on stable internet connectivity remain challenges that require attention in future development. With its promising prospects, ARANOMI has the potential to be further expanded not only within nursing education but also across various health-related disciplines, thereby broadening its contribution to improving educational quality and promoting public health awareness.

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