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# Development of augmented reality-based learning media for health material in physical education, sports and health

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**ABSTRACT**
This study aimed to develop an Augmented Reality (AR)-based learning medium for health topics within Physical Education (PE) subjects at the vocational high school level. The research employed the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation phases. Data were collected through expert validation, teacher assessments, and student response questionnaires during limited and large-scale trials. The validation involved media experts and PE teachers to assess the feasibility and quality of the developed AR media, while students participated in testing to evaluate usability and engagement. The results indicated that the media expert validation obtained an average score of 3.78 (very good), and the PE teachers' assessment reached 3.81 (very good). Student responses in both limited and large-scale trials showed an overall mean score of 3.72 (good), with the highest aspect being media display and design (3.76) and the lowest being content comprehension (3.68). These findings demonstrate that the AR-based media is feasible, effective, and engaging for use in health education within PE, enabling students to visualize and understand the structure and function of human organs and the effects of physical activity in a more concrete and interactive way. Conclusion health-based Augmented Reality (AR) learning media has the potential to increase the meaningfulness of physical education learning through interactive visualization of Health Concepts. Further research needs to assess the effectiveness, expansion of content, technology integration, and sustainability of the application of AR media.
**Keywords:** augmented reality; health material; physical education; sport; health learning



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## INTRODUCTION

Physical Education, Sports, and Health in Vocational High Schools plays an important role in shaping students who are physically, mentally, and socially healthy. physical education,sport and health learning not only emphasizes physical activity but also includes understanding health concepts and the functions of the human body. One important topic in the health aspect is the understanding of body organ systems such as the heart, lungs, and muscles, which play a crucial role in maintaining

fitness and endurance. However, in practice, the learning process in schools still mostly uses conventional methods such as lectures and two-dimensional media (pictures or videos), which are less effective in illustrating the real structure and function of organs (Eroğlu et al., 2023; Feng et al., 2025; Kaikaew et al., 2021). As a result, many students find it difficult to understand the relationships among organs and how body systems work during physical activity.

The limitation of learning media is one of the main causes of students' low conceptual understanding of health-related materials. Learning about organs such as the heart, lungs, and muscles is abstract in nature because these organs cannot be directly observed (Cheung et al., 2021; Y. Liu et al., 2022; Shah et al., 2020). To overcome this issue, the use of interactive, digital-based learning technologies has become an urgent need. One potential technological innovation that addresses this need is Augmented Reality (AR**)**. AR technology enables the combination of the real world with three-dimensional digital elements, allowing students to see and interact with representations of human body organs in a more realistic and immersive way (Mansour et al., 2025; Pregowska et al., 2022; Venkatesan et al., 2021).

Numerous studies in the past decade have shown that AR media can enhance students' motivation, engagement, and learning outcomes. Research by (Bölek et al., 2021; Dhar et al., 2021; Moro et al., 2021) demonstrated that using AR media for human anatomy topics significantly improves student learning outcomes compared to conventional methods. Other studies by (Peterson et al., 2020; Reeves et al., 2021; Triepels et al., 2020) also found that AR is effective in helping students understand organ structures in biology learning through three-dimensional visual interaction. In the context of physical education,sport and healthlearning, research by (Ribelles-García et al., 2021; Shapiro et al., 2023; You et al., 2022) indicated that the use of AR media on physical fitness topics helps students better understand the relationship between physical activity and the functions of body organs such as the heart and lungs.

Rationally, the urgency of this research lies in the need for learning media that can bridge the gap between theory and practice in health education. Materials about the heart, lungs, and muscles are fundamental concepts for understanding physical fitness and cardiovascular health. However, the lack of laboratory facilities or teaching aids in vocational schools makes it difficult for students to visualize how these organs function during physical activity. By using AR, students can observe simulations such as how the heart pumps blood, how the lungs move during breathing, or how muscles contract during movement directly through their digital devices. This is believed to strengthen cognitive understanding and provide a more meaningful learning experience (Heemskerk & Matimba, 2022; Ribelles-García et al., 2021; You et al., 2022).

The research problem arises from the fact that AR-based learning media specifically developed for health materials in physical education,sport and healths ubjects—particularly in vocational school contexts—are not yet available. SMK students have distinct learning characteristics: they are more application-oriented, contextual, and require strong visualizations. Therefore, the development of an initial design of AR media that displays the heart, lungs, and muscles becomes an important first step in integrating innovative technology into physical education,sport and health learning in vocational schools.

This research focuses on the development of Augmented Reality (AR) media as an innovation in learning health material on Physical Education. The need for interactive media that can present concepts of body organs and movement systems in a concrete manner drives the need for the development of technology-based educational products. However, this research does not aim to produce a final product in a full development cycle, but rather to conduct a formative evaluation of the AR prototype that has been designed. The formative evaluation includes expert validation, assessment by Physical Education teachers, as well as limited and extensive trials to assess the feasibility, quality, and response of early users. Thus, the focus of the research is on the initial assessment of the feasibility and potential of AR media, not on testing its effectiveness or learning impact quantitatively in an experimental context.

## METHOD

This study uses the ADDIE model as a development framework, but its implementation is limited to the formative evaluation stage, not the full development cycle. The stages carried out include: (1) Analysis, analyzing the learning needs of physical education,sport and health, health material; (2) Design, designing the AR content structure and display; (3) Development, producing a functional AR prototype; (4) Implementation, conducting limited trials and extensive trials to obtain user feedback; and (5) Evaluation, namely formative evaluation through expert validation, teacher assessment, and student responses. The data collected include media expert validation, physical education,sport and health teacher assessment, and student response questionnaires, which aim to assess the feasibility, quality, and potential use of the media. This study does not include an effectiveness test, because the main focus is to test the feasibility of the AR prototype before further development.

The three-dimensional (3D) models used in the application came from two sources. First, several body organ models, such as the heart, lungs, and muscles, were obtained from open repositories (e.g., Free3D and Sketchfab) under a free-to-use license for educational purposes. Second, simple models, such as illustrations of muscle and bone tissue, were modified and re-rendered using Blender to ensure visual consistency and optimize file size. All models were then converted to FBX format before being integrated into Unity for compatibility with the animation and rendering system

The sample size in this study is based on the principles of formative evaluation in media development research, where the primary goal is to obtain initial feedback on the feasibility and quality of the product, rather than to conduct statistical generalizations or test its effectiveness. Therefore, the use of two trial stages (small group and large group) is in accordance with standard educational R&D practices.

**Table 1. Population characteristics**

| Characteristics | Description |
|---|---|
| Age | 15–18 years |
| Gender | Males and females |
| Grade | 11 |
| Smartphone Ownership | Have Android |

Based on these characteristics, the sampling technique used is purposive sampling. For this reason, a small group trial will be conducted in class XI SMKN 4 Kota Pontianak majoring in audio video engineering, consisting of 15 students., which aims to detect early technical errors and assess the usability of AR media. A broad trial will be conducted on students of XI SMKN 4 Kota majoring in computer network engineering with a total of 60 people. to ensure a more stable response variation and assess user acceptance, interactivity, and perception of media feasibility for general classroom use.

Data collection techniques involved distributing assessment questionnaires to media experts and physical education,sport and health teachers, as well as student response sheets during the limited and extensive trials. The instruments were designed using a four-point Likert scale covering several aspects, including visual and design quality, ease of use, interactivity, and the relevance of content to health education in physical education,sport and health learning.

Data were analyzed using both descriptive quantitative and simple qualitative methods. Quantitative data obtained from validation and trial scores were analyzed by calculating mean values and percentages to determine the level of feasibility of the media. Qualitative data derived from expert suggestions and student feedback were analyzed descriptively to provide recommendations for design improvements. The results of these analyses served as the basis for revising and refining the AR media prototype until it reached a feasible version for further development.

Through these stages, the study produced an initial design and prototype of an Augmented Reality (AR)-based learning media that had been validated by experts and tested through limited and extensive trials in the SMK context. The final product is expected to serve as an innovative learning

tool that enhances students' conceptual understanding of health-related materials in physical education,sport and health learning.

## RESULTS

### Validation Results From The Media Expert

**Table 2. Summary of Media Expert Validation Scores**

| No. | Aspect | Number of Items | Maximum Score | Score Obtained | Percentage (%) | Category |
|---|---|---|---|---|---|---|
| 1. | a. Visual Appearance and Design | 4 | 16 | 14 | 87.5% | Highly Feasible |
| 2. | b. Media Functionality | 3 | 12 | 11 | 91.7% | Highly Feasible |
| 3. | c. Interactivity and Navigation | 3 | 12 | 11 | 91.7% | Highly Feasible |
| 4. | d. Technological and Learning Relevance | 5 | 20 | 18 | 90.0% | Highly Feasible |
| **Total** | 15 | 60 | 54 | **90.0%** | **Highly Feasible** | |

Based on the validation results from the media expert, the Augmented Reality (AR) learning media for physical education,sport and healt materials obtained a total score of 54 out of 60, or 90.0%, which falls into the "Highly Feasible" category for classroom implementation. The expert provided positive feedback, noting that the visual appearance and design were appropriate for the characteristics of vocational students, featuring attractive colors and animations. The functionality of the AR application operated smoothly and stably without any errors during marker scanning. User interactivity was considered high, as students could directly interact with 3D models of human organs and accompanying audio narration. Moreover, the alignment with physical education,sport and health learning objectives was deemed very strong, particularly in facilitating students' understanding of the functions of the heart, lungs, and muscles.

### Physical Education,Sport And Health Teacher Validation Results

**Table 3. Summary of physical education,sport and health teacher validation scores**

| Aspect | Number of Items | Maximum Score | Score Obtained | Percentage (%) | Category |
|---|---|---|---|---|---|
| Content Relevance to Curriculum | 2 | 8 | 8 | 100% | Highly Feasible |
| Media and Design Quality | 2 | 8 | 7 | 87.5% | Highly Feasible |
| Usefulness in Learning | 2 | 8 | 8 | 100% | Highly Feasible |
| Interactivity and Student Engagement | 2 | 8 | 8 | 100% | Highly Feasible |
| Ease of Implementation by Teachers | 2 | 8 | 7 | 87.5% | Highly Feasible |
| Technological Feasibility and Support | 2 | 8 | 7 | 87.5% | Highly Feasible |
| **Total** | 12 | 48 | 45 | **93.75%** | **Highly Feasible** |

Based on the validation results from physical education,sport and health teachers at vocational high school, the Augmented Reality (AR) learning media for physical education,sport and health. Materials obtained a total score of 45 out of 48**, or** 93.75%**,** which is categorized as "Highly Feasible" for classroom use.Teachers stated that the media was highly effective in explaining abstract concepts such as the functions of the heart, lungs, and muscles. They also noted that the AR media supported students' engagement and made it easier for teachers to deliver complex health material in an interactive and visual manner.

**Small Group Trial**

The small group trial was conducted with 15 vocational high school students to evaluate the quality and feasibility of the *Augmented Reality (AR)-based learning media* developed for *physical educatian,sport and health*, particularly in the health materials domain. The assessment employed a four-point Likert-scale questionnaire (1 = Strongly Disagree, 4 = Strongly Agree), encompassing five key aspects: (1) media appearance and design, (2) ease of use, (3) engagement and interactivity, (4) material comprehension, and (5) user impression and satisfaction.

**Table 4**. Description of Small Group Trial Results (N = 15)

| No | Assessed Aspect | Assessment Indicator | Mean Score | Percentage (%) | Category |
|---|---|---|---|---|---|
| 1 | Media Appearance and Design | Attractive display, clear colors, readable text | 3.67 | 91.75 | High |
| 2 | Ease of Use | Easy to operate, clear instructions, easy to learn | 3.64 | 91.00 | High |
| 3 | Engagement and Interactivity | Increases students' interest and participation | 3.61 | 90.25 | High |
| 4 | Material Comprehension | Enhances understanding of organs and body movement systems | 3.58 | 89.50 | High |
| 5 | Impression and Satisfaction | Provides enjoyment and desire for repeated use | 3.63 | 90.75 | High |
| **Overall Mean** | | | 3.63 | 90.75 | High |

The findings revealed that the media appearance and design aspect achieved the highest average score (M = 3.67), suggesting that the AR media offered an appealing visual display with clear colors and legible text, which enhanced students' learning comfort. The ease of use aspect (M = 3.64) indicated that most students found the media easy to operate and the provided instructions straightforward, confirming that the application met *user-friendly* criteria.

In terms of engagement and interactivity (M = 3.61), students expressed strong enthusiasm for learning through AR and indicated a desire to use it again outside classroom sessions. This demonstrates that the interactive 3D visualization successfully encouraged active and participatory learning. The material comprehension aspect (M = 3.58) showed that AR media significantly aided students' understanding of human body functions and movement systems by presenting more concrete and contextualized visualizations than traditional two-dimensional images. Lastly, the impression and satisfaction aspect (M = 3.63) confirmed that students enjoyed using AR media, expressed interest in applying it to other subjects, and were willing to recommend it to their peers.

Overall, the mean score of 3.63, categorized as *high*, demonstrates that the AR-based learning media is both attractive and pedagogically effective. It provides engaging, interactive, and enjoyable

learning experiences that enhance comprehension and motivation in physical education,sport and health topics.

## Large Group Trial

Following the small-scale trial, a large group trial was conducted to further evaluate the usability and effectiveness of the AR learning media. The evaluation involved a broader group of vocational high school students using the same assessment instrument and criteria.

**Table 5**. Results of the Large Group Trial of AR-Based physical education,sport and health Media

| No | Assessed Aspect | Mean Score | Percentage (%) | Category |
|---|---|---|---|---|
| 1 | Media Appearance and Design | 3.76 | 94.0 | Excellent |
| 2 | Ease of Use | 3.72 | 93.0 | Excellent |
| 3 | Engagement and Interactivity | 3.70 | 92.5 | Excellent |
| 4 | Material Comprehension | 3.68 | 92.0 | Excellent |
| 5 | Impression and Satisfaction | 3.74 | 93.5 | Excellent |
| | **Overall Mean** | **3.72** | **93.0** | **Highly Feasible** |

The media appearance and design aspect received the highest mean score (M = 3.76; 94%), indicating that students found the AR visuals attractive, with harmonious color combinations and readable text. The ease of use aspect (M = 3.72; 93%) demonstrated that students could operate the application effortlessly and understand the usage guidelines without difficulty.

Meanwhile, the engagement and interactivity aspect (M = 3.70; 92.5%) showed that the AR's interactive features effectively fostered curiosity and student participation during lessons. The material comprehension aspect (M = 3.68; 92%) revealed that the AR media enhanced conceptual understanding of body organ functions, muscular systems, and the physiological impact of physical activities. The impression and satisfaction aspect (M = 3.74; 93.5%) reflected students' positive emotional engagement and enthusiasm, with many expressing interest in using similar media for other subjects.

One aspect that requires attention is why students' comprehension scores were lower than those for the media's display and design. This finding indicates that although Augmented Reality (AR) can attract attention and increase learning motivation through three-dimensional visualization, it does not automatically guarantee improved conceptual understanding. This may be due to the potential increased cognitive load when students have to process complex AR visual elements without adequate pedagogical scaffolding. Pedagogically, this situation suggests the need to integrate AR with more structured learning strategies, such as through instructional guides, reflective tasks, or prompt questions, so that AR visualizations can truly support the process of internalizing concepts. Furthermore, the potential for social bias also needs to be considered. Because AR is a new technology for most students, their enthusiasm may lead to positive assessments of the medium even though their understanding of the content is not optimal. Students may give good scores because they find the AR learning experience more engaging, rather than because they truly understand the material presented.

Overall, the average score of 3.72 (93%) demonstrates that the AR-based learning media is highly feasible and effective for use in physical education,sport and health education. The media successfully enhances conceptual understanding, increases learning motivation, and provides an enjoyable and interactive experience. Therefore, it is recommended for broader implementation in physical education,sport and health learning activities at vocational high schools.

## DISCUSSION

Based on the results of the media expert validation, the Augmented Reality (AR) learning media for physical education,sport and health materials achieved an average score of 3.71, categorized as Highly Feasible. This finding indicates that the AR media met the eligibility criteria in terms of visual appearance, technological functionality, interactivity, and alignment with learning needs. The highest-rated indicators were "The interface design is attractive and age-appropriate for vocational students"and "AR animations and illustrations support material comprehension."

These results are consistent with the findings of (Maier, 2025; Shangguan et al., 2020; Teplá et al., 2022), who concluded that visually appealing design and relevant animations enhance student attention and facilitate understanding of abstract scientific concepts. Accordingly, the visual design of this AR media has effectively supported students' comprehension of human organ functions—such as the heart, lungs, and muscles—through interactive three-dimensional representations.

Furthermore, this aligns with the studies of(X. Liu et al., 2020; Sahiti & Stamp, 2022), who emphasized that combining text, images, and animation strengthens the *dual-coding system* in the human brain. When students see and hear information simultaneously, they build more complete mental models. The developed AR media successfully applies this principle, as the 3D organ visualizations on screen are accompanied by synchronized audio narration and explanatory text.

Validation by physical education,sport and health teachers also yielded an average score of 3.67 (*Highly Feasible*). Teachers reported that the AR media was very helpful in explaining abstract concepts that are difficult to convey verbally. They further noted that the media increased student engagement and simplified the delivery of health-related materials. The highest ratings were given to the aspects of *instructional usefulness* and *student interactivity*. These findings are in line with research by (Abdullah et al., 2022; Aydoğdu, 2022; Moreno-Guerrero et al., 2020), who found that AR-based learning tools help teachers transform abstract learning materials into more concrete and engaging experiences. By using AR, teachers can visually demonstrate how organ systems function directly in the classroom, making learning time more efficient and enhancing conceptual understanding.

Teachers also appreciated the ease of use of the AR media without requiring extensive technical training, indicating that the product met the principle of *usability*. However, it was noted that devices with lower specifications may experience slight delays during AR marker scanning. Similar findings were reported by (Cao et al., 2023; Gómez-Rios et al., 2023) , who explained that AR performance depends on device capacity and camera stability.

The results of the small-group trial (N = 15) revealed highly positive student responses, with an average score of 3.73 (*Strongly Agree*). Students expressed that the media was enjoyable, easy to use, and helpful in understanding organ functions visually. The highest ratings were observed in the aspects of *interactivity* and *material comprehension*. Students demonstrated high enthusiasm and even wished to continue using the media outside class hours. These findings support prior research by (Y. Liu et al., 2022; Mokmin et al., 2025; Shekerbekova et al., 2025), which indicated that interactive AR media can significantly increase student engagement and learning motivation, particularly in physical education contexts. AR technology encourages active learning, as students directly interact with learning objects rather than passively listening to teacher explanations.

The large-group trial (N = 60) produced consistent results, with an average score of 3.76 (*Strongly Agree*). This indicates that the AR media remained effective when applied in larger classroom settings. Students' positive responses were particularly strong in the aspects of *interactivity* and *health concept understanding*. They described the learning process as more *"alive"* and less monotonous. Effective learning occurs when students construct understanding through active experiences and interaction with learning environments (Cheung et al., 2021; Kadek Suartama et al., 2020; Qureshi et al., 2023). AR technology provides an immersive learning context that encourages students to explore and discover concepts independently.

Overall, the formative evaluation results demonstrate that the developed AR media is both content- and design-valid, and is feasible for use in physical education,sport and health learning at vocational schools. The media addresses 21st-century learning demands by integrating technology

and enhancing digital literacy. Although this study is still in its preliminary stage (without an experimental effectiveness test), the formative results suggest that the product holds strong potential to improve students' conceptual understanding and engagement.

These findings support those of (AlGerafi et al., 2023; Gómez-Rios et al., 2023; Kennedy et al., 2021), who stated that using AR in education fosters curiosity and emotional engagement during learning. Thus, the developed AR media is not merely a visual aid but a transformative learning tool that enriches both cognitive and affective dimensions of the physical education,sport and health learning process.

These limitations include the lack of cognitive effectiveness measurements through learning outcome tests, so this study cannot conclude whether AR significantly improves conceptual understanding. Furthermore, learning implementation that relies heavily on students' mobile devices has the potential to cause variations in the quality of the learning experience, especially for students with lower device specifications. The study's results also have limited generalizability because they only involved a sample from one school with a limited number of respondents. The learning curve for teachers in operating AR has also not been thoroughly evaluated, even though teacher skills influence the success of media implementation. Therefore, further research is needed to test the effectiveness of AR based on cognitive data, expand the sample, and evaluate teacher readiness to ensure that AR use truly provides optimal pedagogical impact.

## CONCLUSION

The development of health-based Augmented Reality (AR) learning media on physical education, sports, and health subjects has strong potential to support a more meaningful learning process. AR integration is able to bridge abstract health concepts into visual-interactive learning experiences that are relevant to the context of vocational education, thus enriching learning approaches and opening up innovation opportunities in physical education. Further research is suggested to test the effectiveness of AR media on improving learning outcomes quantitatively through experimental design, expanding the scope of health or educational materials, and integrating AR with other technologies such as virtual reality or learning analytics. In addition, studies on long-term implementation and readiness of school infrastructure are also important to ensure the sustainability of the use of AR media in learning.

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## CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the conduct, results, or publication of this research.

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