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LEARNING MEDIA DEVELOPMENT OF AUGMENTED REALITY HAIR COLORING

Asi Tritanti[1], Eni Juniastuti[2], Ika Pranita[3], Mausa Agrevinna[4], Arasinah Kamis[5]
Universitas Negeri Yogyakarta, Indonesia[1,2,3,4]
Universiti Pendidikan Sultan Idris, Malaysia[5]
E-mail: asi_tritanti@uny.ac.id

Abstract
This study addresses the challenges of conventional teaching methods in cosmetology education by developing a mobile Augmented Reality (AR) application for hair coloring. The primary objective is to enhance students' learning experiences and achievements through interactive AR content. Using the ADDIE model, we created an Android-based AR system that integrates Vuforia Engine for marker-based tracking and ARCore Face API for facial recognition. The methodology involved a descriptive analytical approach with expert validation to assess usability and content accuracy, followed by user testing with final-year students. The findings reveal that while the AR application has potential, it faces technical challenges, including prolonged download times and device compatibility issues. The implications of this research highlight the need for improvements in user interface design, system stability, and content accuracy to optimize the learning experience. By addressing these issues, the study aims to contribute to the effective integration of digital technologies in vocational education, ultimately preparing students for success in the beauty industry.

Keywords: Augmented Reality; vocational education; hair coloring; mobile learning; ADDIE model

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Corresponding: Asi Tritanti
E-mail: asi_tritanti@uny.ac.id

INTRODUCTION

Conventional teaching (whiteboard/PowerPoint) is considered less relevant and less interactive according to current conditions. For this reason, innovation in learning media is needed, one of which is Augmented Reality (AR). With AR, students can see holographic 3D objects directly in class via mobile phones, making learning more immersive. Utilizing M-Learning (mobile learning) can increase student creativity, motivate and encourage collaboration. The form of implementation is the development of an Android application that converts material into interactive AR content (Arulanand et al., 2020; Geary et al., 2023; Neges et al., 2019; Nurmaena & Gumiandari, 2022; Stechert & Yengui, 2022).

Learning media is recognized as one of the determining factors for successful learning, because learning media can increase student motivation, which is expected to be actively involved so that learning is more meaningful. Learning media is one of the determining factors in increasing student understanding because learning media is a channel or intermediary used to convey messages or teaching materials. In the application of learning media and learning methods, students learn actively in the digital-based learning revolution. One of the accesses that can be used to obtain information includes the Internet and smartphones.

The use of appropriate learning media can help communication in the learning process so that it is more effective. One of the learning media used is New Media (-, 2017; Arief &

Umniati, 2012; Khoirianti et al., 2022; Mastuti et al., 2021; Ridwan, M, Zulhajji, 2021). New media is Augmented Reality (AR) which is applied to Android-based mobile phones. Augmented reality is a media that has the potential to increase accuracy (Alanazi et al., 2024; Bagwe et al., 2021; Jud et al., 2020; Sun et al., 2023). This is in line with visualizing the anatomy of hair in the hair coloring process in the hair coloring AR content.

The development of learning media in the Hair Coloring course is very necessary to improve the quality of learning, in this case the development of learning media is directed at creating Augmented Reality related to how the coloring process in hair is applied to Android-based mobile phones that can be used in digital-based learning and as an alternative learning media that is more interesting for learners.

Augmented reality as an interactive technology that combines virtual objects of different dimensions will create a mixed combined space (Mixed Reality) to then be projected in real time, so it is also called an interactive technology that combines the real world and the virtual world (Dewi, 2022; Qorimah & Sutama, 2022). AR technology has a similar principle to Virtual Reality (VR), but the integration of objects in AR is the opposite of VR. In VR, real objects (users) are combined into a virtual environment, while in AR, virtual objects are combined into a real environment. Augmented Reality (AR) offers an innovative solution to visualize the complex chemical process of hair coloring through the placement of virtual objects. Technically, hair coloring involves three main procedures: (1) hair tinting (adding color pigments to cover gray hair), (2) hair lightening (lightening the color in corrective coloring), and (3) bleaching (removing pigments as the basis for more radical color changes). These three processes involve complex chemical reactions that are abstract and difficult to understand through conventional explanations.

The implementation of AR as a strategic learning medium provides several advantages. In the cognitive aspect, AR can visualize the microscopic process of chemical reactions in an immersive mixed-reality manner. In the psychological aspect, it can reduce learning anxiety through positive experiences (Sahin & Yilmaz, 2020), and in the interactive aspect, AR allows manipulation of virtual objects and contextual interactions (Mahale & Yeddu, 2016; Soltani & Morice, 2020)

Although the effectiveness of AR has been proven in the medical field, its application in cosmetology education, especially to visualize the complexity of hair coloring procedures, has not been widely explored. Recent research shows that the benefits of AR.LRP (Augmented Reality Learning and Retention Process) include four main dimensions, namely Personal (skill enhancement), Emotional (reduced learning anxiety), Cognitive (conceptual understanding), and Telepresence (Baabdullah et al., 2022; Jud et al., 2020).

The development of a mobile Augmented Reality (AR) application for hair coloring education in cosmetology programs presents several critical challenges. Despite the potential benefits of using AR to enhance learning experiences, there are significant technical and pedagogical hurdles that need to be addressed. These include issues related to user interface design, system stability, and the accuracy of educational content, which can impact the overall effectiveness of the learning tool.

The urgency of this research is emphasized by the rapid advancement of digital technology in education, particularly in vocational training settings such as cosmetology. As educational institutions increasingly adopt innovative learning methods, it is vital to evaluate and refine these technologies to ensure they meet educational objectives effectively. Failure to address the challenges associated with AR in education could lead to wasted resources and missed opportunities for enhancing student engagement and learning outcomes.

Moreover, with the growing demand for skilled professionals in the beauty industry, it is essential to develop effective educational tools that not only improve technical skills but also

foster creativity and innovation among students. Ensuring that AR applications are effective and user-friendly will play a crucial role in preparing students for success in their future careers.

Previous studies have explored various aspects of Augmented Reality in education, highlighting both its potential and its limitations. For instance, Azuma (1997) conducted a foundational survey of AR technologies, demonstrating their applicability in educational contexts and the importance of user experience. More recent research by Chang et al. (2022) indicated that AR can significantly enhance practical performance and conceptual understanding in vocational training, emphasizing the need for immersive learning experiences.

Additionally, a study by Zhang et al. (2022) investigated the factors influencing the acceptance of AR in educational settings, identifying user engagement and interactivity as critical components for success. However, it also noted that technical challenges, such as device compatibility and performance issues, could hinder the implementation of AR technologies in classrooms.

Furthermore, research by Baabdullah et al. (2022) found that while AR can improve learning motivation, its effectiveness often depends on the design and content quality of the application. This underscores the necessity for careful consideration of both technical and pedagogical aspects when developing AR learning tools.

Despite the existing body of research, there remains a significant gap in understanding the specific technical and pedagogical challenges associated with implementing AR in cosmetology education. Most studies have focused on broader applications of AR in various educational contexts without addressing the unique needs and conditions of vocational training programs, particularly in hair coloring.

This research introduces a novel approach by utilizing the ADDIE model to systematically develop and evaluate an AR application specifically designed for hair coloring education. By focusing on the unique challenges of this vocational context, the study aims to provide targeted insights and recommendations for improving AR learning tools in cosmetology.

The primary objective of this study is to develop a mobile AR application for hair coloring education and evaluate its effectiveness in enhancing learning outcomes among cosmetology students at SMPN 10 Samarinda. The research aims to identify technical and pedagogical challenges and propose solutions to optimize the application for educational use.

The findings of this research will benefit educators, curriculum developers, and technology providers by offering evidence-based insights into the development and implementation of AR applications in vocational education. By addressing the identified challenges, this study aims to contribute to the creation of more effective and engaging learning tools that enhance students' skills and prepare them for professional success in the beauty industry.

METHOD

This research employs a Research and Development (R&D) methodology, specifically utilizing the ADDIE development model, which encompasses five key stages: analysis, design, development, implementation, and evaluation. The ADDIE model is particularly effective in educational contexts as it provides a structured framework for creating learning materials and assessing their effectiveness. In the analysis phase, various factors are considered, including the characteristics of learning in the digital age, the needs of the millennial generation, and the evolving role of educators. This foundational analysis is crucial for tailoring the Augmented Reality (AR) application to meet the demands of contemporary learning environments.

In the design phase, the research focuses on developing the learning media elements, which include text, narration, images, audio, video, and animations. The interface design is

also a critical aspect, ensuring user compatibility and ease of navigation. This involves creating an intuitive user experience (UX) that promotes interaction and engagement. Additionally, the design of markers—real objects that link the physical and virtual worlds—is crucial for effective AR functionality. Various software tools, such as Adobe Director and 3D Studio Max, are selected to facilitate the creation of high-quality AR content that enhances the learning experience.

The development stage involves rigorous validation of the AR learning media by experts in various fields, including material content, media design, and programming. This validation process ensures that the product is feasible and aligns with educational objectives. Following validation, the implementation phase sees the AR media introduced to users, allowing for practical testing in real educational settings. Finally, the evaluation phase assesses technical quality, content accuracy, and instructional effectiveness, providing insights for further refinement and optimization of the AR application in cosmetology education.

RESULTS AND DISCUSSION

The AR system was developed using Unity 3D with integration of Vuforia Engine for marker-based tracking and ARCore Face API for face tracking. Digital assets include 3D models of hair color variations (created with 3D modeling tools) and video tutorials (produced using Adobe Premiere Pro with custom scripts and storyboards).
The development procedure is presented in Figure 1.

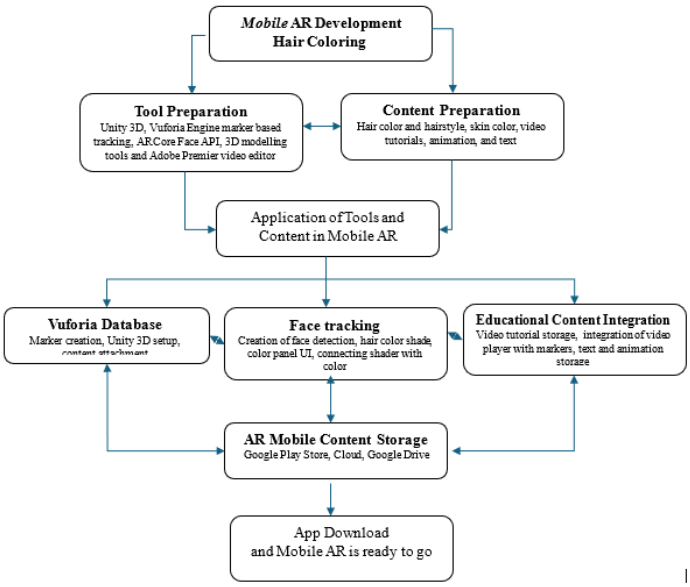

Figure 1. Hair Coloring Mobile AR development procedure

The results of the Media Expert Validation obtained an actual score of 74%. With a feasibility criterion of ≥75%, the results were declared Not feasible (requires revision). The main finding was that there were 8 items rated "Disagree" especially in the aspects of the interface and system stability. The results of the Material Expert validation obtained an actual score of 78.57%. with a feasibility criterion of ≥75%, the results were declared Eligible with critical findings: 3 items "Disagree" on the aspect of the accuracy of the coloring chemical content.

Based on these results, recommendations for improvement focus on: 1) improving the user interface (UI/UX), 2) increasing the stability of the tracking system, 3) revising the coloring chemical content for scientific accuracy, and 4) optimizing performance for mid-range

devices. Although the material is declared feasible, the product requires technical improvements before implementation in learning. This study provides a methodological framework for the development of an AR system in makeup education with a comprehensive validation approach.

In the limited user trial, five trial respondents were selected through purposive sampling with the criteria of final semester students. The evaluation protocol includes: (1) downloading the application through the Google Play Store platform, (2) a thorough exploration of all application features, and (3) filling out the assessment instrument. The evaluation scale uses the criteria Very Good: 4.5-5.0, Good: 3.5-4.4, Sufficient: 2.5-3.4, and Less: <2.5.

The results of the trial based on the distribution of evaluation scores, obtained the following results: 11 items obtained an average score of 4.0 (Good category), 3 items achieved an average of 3.8, and 2 other items achieved an average of 3.6 (both in the Sufficient category). Items 11 and 12 which obtained the lowest scores require more in-depth analysis. Based on qualitative responses from a limited test of 5 users, several critical issues were identified, namely: 1) Compatibility and Performance Issues, where 60% of respondents (n=3) reported significantly longer application download times compared to similar applications on the Google Play Store, 20% of respondents (n=1) experienced iOS operating system compatibility issues, and 20% of respondents (n=1) with low-end devices were unable to download the application. 2) Functionality Issues where the face tracking system requires optimal lighting conditions (no backlight), a significant increase in device temperature after several minutes of use, and latency in navigating between menus when buttons are accessed randomly.

These findings indicate several key technical challenges:

1. Suboptimal application package (APK) size
2. Platform restrictions for Android only
3. High hardware specification requirements
4. Face tracking algorithms that are sensitive to light conditions
5. Excessive computational load on key components

The development of mobile AR for hair coloring learning is an innovation in makeup learning media, especially in visualizing the complex chemical processes that occur during hair color changes. This system was developed by considering the composition of makeup learning consisting of 30% theory and 70% practice. The selection of AR technology is based on its proven ability to significantly improve practical performance (large effect), conceptual understanding (medium-large effect), and learning engagement (Chang et al., 2022).

Based on the Technology Acceptance Model (TAM), the adoption of AR technology in education is influenced by four main factors: (1) visual appeal and entertainment elements, (2) level of system interactivity, (3) ease of operation and practical benefits, and (4) user confidence. The implementation of AR has also been shown to be effective in improving the quality of vocational training (Chiang et al., 2022), while also addressing the challenges of modernizing learning resources.

Product Evaluation and Revision

Validation by media experts identified several technical weaknesses in:

1. Technical quality (program description malfunction)
2. Usability aspects (operational difficulties)
3. Visual elements (inconsistency of button functions and interactive pages)

While material experts noted the need for improvement in:

1. Relevance of content to learning objectives
2. Feedback system
3. Up-to-dateness of materials

Further analysis revealed that the main technical issues included suboptimal JavaScript callbacks causing latency, in addition to excessive computational load from face tracking, video, and animation, and inefficient memory management during transitions between menus. Optimization strategies implemented in the improvement steps carried out include:

1. Implementation of visual feedback for button interactions
2. Optimization of JavaScript code
3. Compression of multimedia assets (video and animation)
4. Simplification of 3D hair models (<10,000 polygons)
5. Adjustment of the face tracking algorithm
6. Determination of minimum device specifications (Android 10+, RAM ≥4GB, Snapdragon 700 series chipset)

The edge/fog computing approach E. S. Lee & Shin (2023) and Mobile Cloud Computing integration Junior et al. (2019) were applied to improve system performance. The results of limited trials showed long download times (60% of respondents), application incompatibility with iOS devices (20%) because it was designed using tools for Android, overheating that occurs on devices with low-end specifications (20%), sensitivity of face tracking to lighting conditions, and latency of navigation between menus.

These findings confirm several basic principles of AR implementation, namely:

1. Dependence on device specifications (Cao et al., 2020)
2. The importance of thermal optimization (K. M. Lee et al., 2018)
3. The complexity of real-time rendering
4. Intuitive interface design principles

Despite facing technical challenges, this mobile AR system shows great potential in increasing user self-efficacy, reducing user technology anxiety, and strengthening engagement. For further improvement, it is recommended to develop a cross-platform version of the mobile AR application, by implementing adaptive thermal management (ATM), refining computer vision algorithms, testing with more diverse samples, and integrating learning analytics to evaluate learning impact.

CONCLUSION

The Hair Coloring AR media has demonstrated effectiveness as a learning tool specifically designed for makeup education, integrating cognitive aspects with multimedia components such as instructional videos, an object recognition system, a structured material presentation, and appealing interface aesthetics. While it enhances learning outcomes by providing advance organizers and explanatory captions, the implementation faces technical challenges, including system load issues due to the coexistence of various tracking methods and performance problems stemming from decreased accuracy during video playback and increased storage requirements. These complexities highlight the need for careful content selection, limiting the amount and type of material based on learning priorities, and dividing content into separate, downloadable modules. Future research should explore the long-term effectiveness of AR in vocational education, investigate user experiences with varying content structures, and assess how optimizing technical specifications can further enhance the learning experience in diverse educational contexts.

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