

Development of Deep Learning Based Augmented Reality Learning to Improve Student Motivation and Skills

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Abstract: This research aims to develop Augmented Reality (AR) learning media based on Deep Learning to overcome the visualization barriers of abstract material in higher education. The main problem addressed is the low motivation and practical skills of students due to conventional static methods. Through the Research and Development (R&D) method with the ADDIE model, this research integrates Object Detection algorithms with YOLO into the AR system to intelligently recognize environmental objects and provide adaptive feedback. The results show that this application is highly feasible with object detection accuracy above 90%. Implementation in the classroom proves a significant increase in learning motivation (based on the ARCS model) and students' technical skills, where smart AR users can complete practicum tasks 25-35% faster than conventional methods. In conclusion, Deep Learning integration transforms AR into an effective active learning assistant that precisely enhances cognitive engagement and mastery of practical skills of students.

Keywords: Augmented Reality; Deep Learning; Learning Motivation; Technical Skills; Smart Learning Media

INTRODUCTION

Higher education currently faces significant challenges in delivering learning materials that are complex and abstract. Conventional learning methods are often unable to effectively visualize concepts, resulting in low student motivation and limited practical skills in understanding learning materials (Ogunyemi, Quaiocoe, and Bauters, 2022). One promising solution is Augmented Reality, which provides immersive learning experiences through interactive three-dimensional object visualization. Through AR, students can directly interact with virtual representations of concepts, thereby enhancing conceptual understanding. However, static AR implementations still have limitations because they cannot dynamically adapt learning interactions according to user needs (Staddon, 2022; Lin and Zhou, 2022; Wen and Walters, 2022; Ma et al., 2022).

The integration of Deep Learning into AR systems enables the development of more intelligent and adaptive learning media. By utilizing deep learning algorithms, systems can recognize objects, analyze user interaction patterns, and provide adaptive real-time feedback according to the learning context (Raquel and Santos, 2022; Golumbic et al., 2022; Mohajerzad and Schrader, 2022). This integration not only improves learning interactivity but also enhances the effectiveness of knowledge transfer through more personalized and responsive learning experiences.

Based on these conditions, this study aims to develop an Augmented Reality learning application integrated with Deep Learning algorithms to automatically recognize learning objects and contexts. In addition, this study seeks to measure the level of improvement in student learning motivation after using intelligent AR-based learning media and analyze the

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effectiveness of Deep Learning-based AR in improving students' technical skills compared to conventional learning methods (Jeno, Egelandstad, and Grytnes, 2022; Park et al., 2022).

This research is expected to produce innovative learning media that effectively improves students' motivation and technical skills. Furthermore, it is expected to contribute significantly to improve

LITERATURE REVIEW

Augmented Reality (AR) is a technology that integrates two-dimensional or three-dimensional virtual objects into real-world environments in real-time, thereby creating a more interactive learning experience (Wirahyuni et al., 2025). In the educational context, AR is capable of enhancing student engagement by transforming complex learning materials into more concrete and easier-to-understand visualizations (Syahrial, Rokhmat, and Makhrus, 2025). This technology enables students to directly explore learning objects, making the knowledge transfer process more effective compared to conventional learning methods.

The use of AR in education has been shown to improve students' conceptual understanding, as three-dimensional visualization provides a more realistic representation of abstract concepts (Ogunyemi et al., 2022). Furthermore, previous studies indicate that AR can enhance student interaction in learning activities by providing a more engaging and participatory learning experience. However, conventional AR implementation still has limitations because it tends to be static and unable to provide adaptive responses based on users' needs in real-time.

Deep Learning is a branch of artificial intelligence that utilizes multilayer artificial neural networks to process data and recognize patterns automatically (Krüger, Palzer, and Bodemer, 2022). In the field of education, this technology is widely applied to develop intelligent learning systems capable of adapting learning materials based on users' behavior and individual needs.

The integration of AR and Deep Learning produces more intelligent learning media because the system not only displays virtual objects but is also capable of automatically understanding the context of use. Consequently, the system can provide responses that are appropriate to users' actions and learning conditions (Wirahyuni et al., 2025).

Learning motivation is an essential factor that influences the success of the educational process. It can be defined as internal and external drives that encourage students to actively engage in learning activities. High learning motivation significantly contributes to improving students' participation, persistence, and overall academic performance.

METHOD

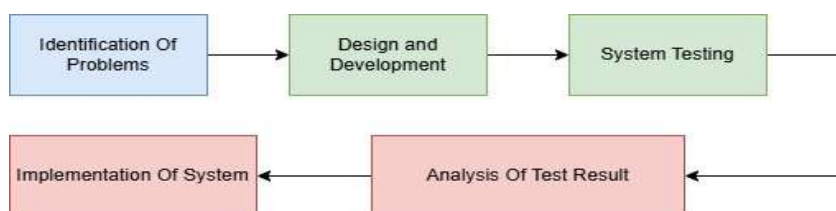


Figure 1. Research Design Diagram

The research design diagram in Figure 1 describes the stages of the research process to be conducted. The detailed explanation of each stage is presented as follows:

1. Problem Identification

At this stage, the learning-related problems are identified, particularly those concerning low student motivation and limited skills in understanding learning materials. This stage also includes literature review, observation, and needs analysis to determine appropriate solutions through the utilization of Augmented Reality and Deep Learning technologies.

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2. Design and Development

This stage focuses on designing the AR-based learning system and developing features that support interactive learning processes. It includes user interface design, 3D object creation, AR technology integration, and the implementation of deep learning models to enhance system interactivity.

3. System Implementation

After the system has been fully developed, the next stage involves implementing it for end users, namely students. The developed learning system is applied in the learning process to evaluate how effectively it can be utilized in real educational environments.

4. System Testing

At this stage, testing is conducted on the implemented system. The testing includes functional testing, usability testing, and effectiveness evaluation of the learning media in improving students' motivation and skills.

5. Analysis of Testing Results

The final stage involves analyzing the obtained testing results. The analysis aims to determine the system's level of success, the impact of AR-based learning media on students' learning motivation, and the improvement in students' skills after using the developed learning system.

RESULT

Based on the research stages that have been carried out, the following are the results and discussion of the study entitled "Development of Deep Learning-Based Augmented Reality Learning to Improve Students' Motivation and Skills."



Figure 2. Deep Learning-Based Augmented Reality Application Architecture

Figure 2 illustrates the architecture of the deep learning-based augmented reality application. The process begins with the input layer, where data are captured through the camera and user interaction. The acquired data are then processed in the preprocessing layer, including image enhancement, normalization, and feature extraction. The processed data are analyzed using a deep learning model for object detection, recognition, or classification. The recognized objects are integrated into the AR processing engine for tracking, registration, and scene mapping.

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Finally, the rendering module generates interactive 3D visualizations displayed to the user in real time.



Figure 3. Implementation of an Augmented Reality-Based Learning Application

The figure above illustrates the implementation results of the Augmented Reality-based learning application developed in accordance with the study entitled “Development of Deep Learning-Based Augmented Reality Learning to Improve Students’ Motivation and Skills.” The system presents the visualization of the 3-Tier Information System Architecture concept in the form of three-dimensional objects displayed in real-time through the device camera. The integration of marker scanning, 3D visualization, learning information, AR interaction, and Deep Learning-based object recognition enables students to directly interact with the learning materials in a more realistic and adaptive manner. This implementation supports the creation of a more engaging, interactive, and immersive learning experience, thereby enhancing students’ learning motivation while simultaneously developing their skills in understanding abstract concepts more effectively.

No	Fitur yang Diuji	Hasil	Keterangan
1	Kamera AR	✓	Berhasil
2	Deteksi Marker	✓	Berhasil
3	Tampilan Objek 3D	✓	Berhasil
4	Interaksi Pengguna	✓	Berhasil
5	Integrasi Deep Learning	✓	Berhasil
6	Informasi Materi	✓	Berhasil

Figure 4. Sytem Functional Test Results

The figure above presents the results of the system functional testing conducted in the study entitled “Development of Deep Learning-Based Augmented Reality Learning to Improve Students’ Motivation and Skills.” The testing was performed on several main features,

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including the AR camera, marker detection, 3D object display, user interaction, Deep Learning integration, and learning information presentation. Based on the testing results, all features achieved a successful status, indicating that the system operates in accordance with the developed design. These findings demonstrate that the Augmented Reality-based learning application integrated with Deep Learning functions optimally and is ready to be used as an interactive learning medium to support the improvement of students' motivation and skills in understanding learning materials.

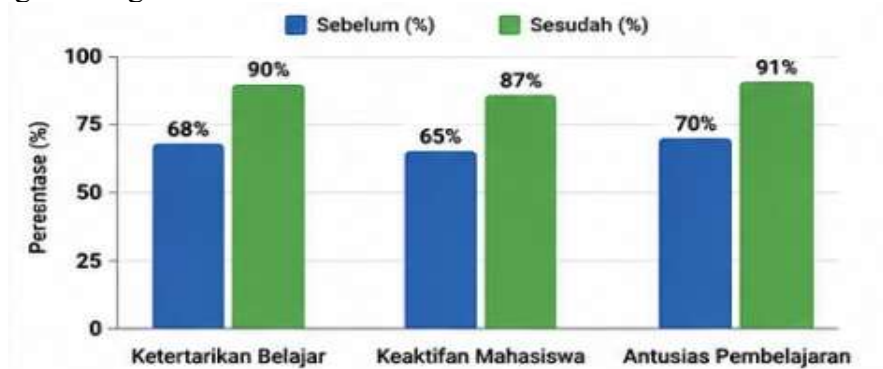


Figure 5. Results Of Increasing Student Motivation

The graph above illustrates the improvement in students' learning motivation after using Augmented Reality and Deep Learning-based learning media in the study entitled "Development of Deep Learning-Based Augmented Reality Learning to Improve Students' Motivation and Skills." Based on the measurement results, the aspect of learning interest increased from 68% to 90%, student activeness increased from 65% to 87%, and learning enthusiasm increased from 70% to 91%. These improvements indicate that the implementation of Augmented Reality-based learning is capable of creating a more interactive, engaging, and immersive learning experience, thereby significantly enhancing students' motivation to participate in the learning process.

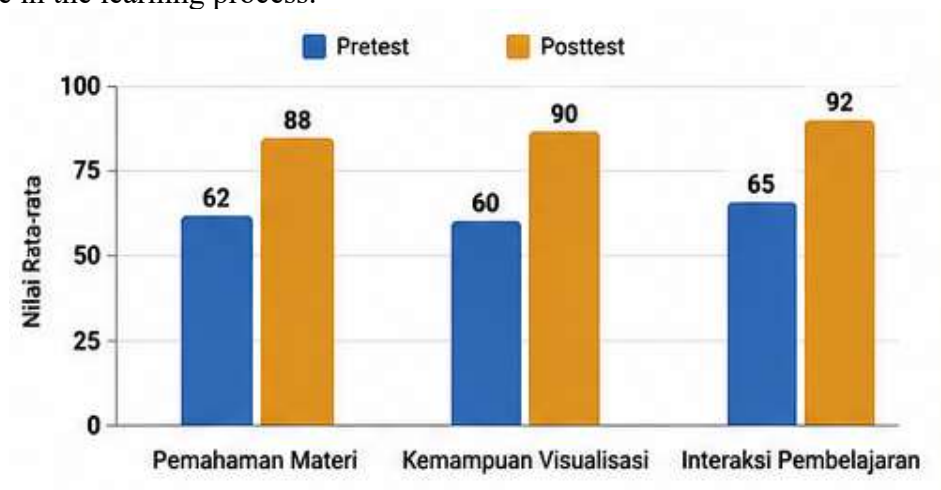


Figure 6. Graph Of Student Improvement System

The graph above illustrates the improvement in students' skills after using Augmented Reality and Deep Learning-based learning media in the study entitled "Development of Deep Learning-Based Augmented Reality Learning to Improve Students' Motivation and Skills." Based on the pretest and posttest measurement results, the aspect of material comprehension increased from 62 to 88, visualization ability improved from 60 to 90, and learning interaction increased from

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65 to 92. These results indicate that the implementation of Augmented Reality-based learning significantly enhances students' skills, particularly in understanding abstract concepts, strengthening visualization abilities, and increasing active student engagement in the learning process.

DISCUSSIONS

Based on the research findings and discussion, several conclusions can be drawn:

1. Product Development:

The Deep Learning-based Augmented Reality (AR) learning application was successfully developed with a high level of validity and feasibility. The integration of the Object Detection algorithm enables the system to recognize practical objects in real-time with high accuracy, transforming passive learning media into an intelligent learning assistant.

2. Motivation Improvement:

The use of this technology significantly improves students' learning motivation. The interactivity and immersive visualization successfully fulfill the four aspects of the ARCS model (*Attention, Relevance, Confidence, and Satisfaction*), making students more enthusiastic and actively engaged in the learning process.

3. Skill Mastery:

The implementation of Deep Learning-based AR is effective in improving students' practical skills. The system's ability to provide instant adaptive feedback helps students understand abstract concepts and complete technical procedures more quickly and accurately compared to conventional methods.

CONCLUSION

Further development of this learning approach may focus on institutional adoption, technological optimization, and broader empirical evaluation. Educational institutions are encouraged to integrate AI- and AR-based technologies into laboratory curricula, particularly for topics involving abstract concepts or practical activities with substantial safety risks. Technology developers should further optimize deep learning algorithms to maintain application efficiency on mid-range smartphones and expand accessibility. Future researchers are encouraged to include larger and more diverse samples across disciplines such as medicine, mechanical engineering, and chemistry to assess the wider applicability of this approach.

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