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Data-Driven Analysis of Computer-Based Testing to Advance Machinist Performance

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Abstract

The rapid advancement of technology has transformed the education sector, offerings new avenues for data-driven teaching and learning innovations. This study investigates the integration of Augmented Reality (AR) technology in developing an interactive learning media application for scout password recognition, with a focus on analyzing learner interaction data to evaluate its effectiveness. The application utilizes marker-based tracking to overlay digital content in the real world, creating an immersive environment that enhances comprehension and retention. The study employs the Prototype Method to ensure user-centric design, supported by stakeholder feedback throughout iterative development. Unified Modeling Language (UML) tools, such as Use Case and Activity Diagrams, were utilized to model system functionality. Key features of the application include interactive 3D models, gamification elements, and progress tracking, with user interaction data analyzed to assess engagement and learning outcomes. System functionality was evaluated using the Blackbox testing method, and user performance data was analyzed to identify patterns in engagement, motivation, and understanding of scout passwords. Results reveal a significant improvement in learner outcomes compared to traditional teaching methods, with data analysis highlighting areas of particular effectiveness, such as the use of gamification to sustain learner interest. This research not only underscores the potential of AR in transforming niche educational contexts but also emphasizes the importance of analyzing interaction and performance data to refine educational tools. Future development recommendations include incorporating AI-powered personalized learning features and expanding the application to cover additional scouting skills, paving the way for broader adoption of AR technology in education.

Keywords

Software, online exam, performance improvement, machinist, prototyping, CBT

Introduction

The rapid evolution of technology has significantly influenced the education sector, introducing new methods and tools that enhance the learning experience. Augmented Reality (AR) is a transformative technology bridging the gap between physical and virtual realities (Kayyali, 2024).

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By overlaying digital content in the real world, AR creates an interactive and immersive learning environment that fosters engagement, understanding, and retention of information (Siricharoen, 2023). This study leverages AR technology to develop a learning media application for recognizing scout passwords, focusing on the marker-based tracking method to deliver accurate and efficient learning outcomes.

Scout password recognition is a critical skill in scouting activities, requiring participants to memorize and interpret symbolic codes used for communication (Davis et al., 2022). This skill has been traditionally taught through printed guides, manuals, or verbal instructions. These conventional methods, while functional, often fail to engage learners due to their static and non-interactive nature. Additionally, these methods rely heavily on rote memorization, which can be tedious and inefficient, especially for younger learners. As a result, there is a need for innovative teaching strategies that address these limitations while enhancing the learning experience.

The use of AR in education has gained substantial attention in recent years, with research demonstrating its effectiveness across various disciplines (Lampropoulos et al., 2022). AR integrates auditory, visual, and kinesthetic elements, creating a multi-sensory learning experience accommodating diverse learning styles. For example, AR applications have been successfully used in language acquisition, science education, and historical studies, allowing learners to visualize and interact with complex concepts tangibly. Marker-based AR, in particular, is widely adopted for its simplicity and precision, using predefined physical markers to trigger corresponding digital content.

Despite the widespread application of AR in education, its use in scouting activities still needs to be explored. Recognizing this gap, this study aims to apply marker-based AR technology to the specific context of scout password recognition. By associating digital animations, 3D models, and interactive features with physical markers, the proposed learning media seeks to transform how scout passwords are taught and learned (Murala, 2024). This approach not only addresses the limitations of traditional methods but also introduces an element of gamification, which has been shown to increase learner motivation and engagement.

The challenges associated with conventional scout password teaching methods highlight the need for innovative solutions. For instance, printed guides are prone to wear and tear, and their static nature fails to capture learners' interest. Similarly, verbal instructions are limited by the instructor's ability to convey complex symbolic systems effectively (Yu et al., 2023). These issues are compounded by the need for more personalization in traditional teaching methods, which often fail to cater to individual learning paces and styles. The proposed AR application aims to overcome these barriers by offering a dynamic, personalized, and visually engaging learning platform.

The marker-based tracking method employed in this study uses physical markers to anchor digital content in the real world. These markers trigger 3D models, animations, and other multimedia elements representing scout passwords (Kulai et al., 2022). By interacting with these digital representations, learners can engagely explore each password's structure, meaning, and context. This interactive approach is expected to enhance comprehension and retention while making learning enjoyable and less intimidating for learners.

From a theoretical perspective, this study draws on constructivist learning theories, which emphasize active participation and interaction as critical components of effective learning. By enabling learners to interact with AR content, the proposed application aligns with constructivist principles, encouraging exploration, experimentation, and self-directed learning. Additionally, the gamification elements incorporated into the application are designed to stimulate intrinsic motivation, fostering a sense of achievement and progression as learners master each scout password.

Regarding technical implementation, the study employs marker-based tracking due to its reliability and ease of use (Arief et al., 2023). This method ensures that the AR content aligns accurately with the physical markers, providing a seamless user experience. The AR application is designed to be accessible on standard mobile devices, eliminating the need for specialized hardware and ensuring the learning tool is widely available. The application also includes features for progress tracking, enabling instructors to monitor learners' development and tailor their teaching strategies accordingly.

This study is significant not only because of its contribution to scouting education but also because of its broader implications for educational technology. By demonstrating the efficacy of AR in a niche context, the research highlights AR's versatility and potential as a tool for addressing diverse educational challenges. Furthermore, the study provides a framework for future research on AR applications, encouraging innovation and exploration in other underrepresented areas of education.

Ultimately, this research seeks to transform how scout passwords are taught, making the process more interactive, engaging, and effective. The proposed AR learning media represents a step forward in integrating modern technology with traditional educational practices, paving the way for more inclusive and effective learning solutions. Through this initiative, the study aims to enhance scouting education and inspire further advancements in using AR for educational purposes.

Methodology Research

In this research, system development uses the Prototype method. Developers widely use this system development method to interact with users during the system development process. The prototype stages can be seen in Figure 1 below:

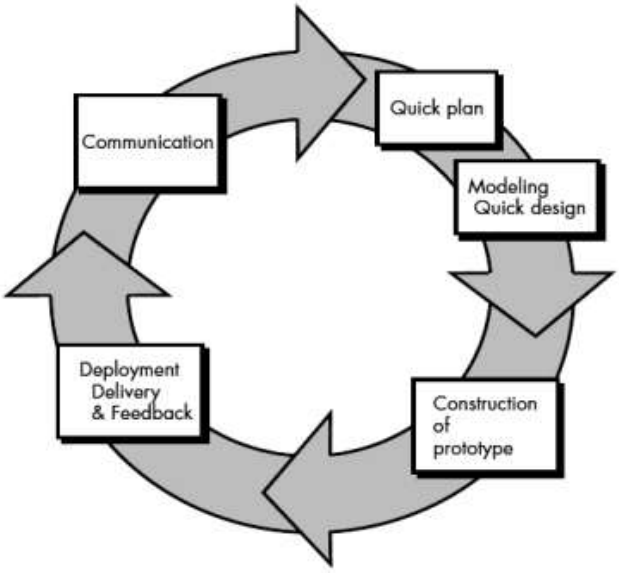

Figure 1. Prototyping Model

The development of an augmented reality (AR) learning media for recognizing scout passwords utilized the Prototype Method, an iterative approach designed to emphasize user interaction and feedback throughout the development process (Xie et al., 2022). This method ensures creating a user-centric application that meets stakeholder needs while continuously refining functionality. Key stages included communication, quick planning, modeling, prototype construction, and deployment, each contributing to the system's design and implementation.

The initial communication stage focused on identifying user requirements by engaging with educators and scouts to understand their challenges with traditional teaching methods. Key issues such as lack of engagement, static content, and inefficiency in teaching were highlighted, shaping the design objectives of the AR application. The subsequent quick planning stage laid a development roadmap, outlining objectives like interactive design, enhanced engagement, and device compatibility.

In the modeling and quick design stage, conceptual models such as Use Case Diagrams and Activity Diagrams were employed to represent system functionality and user interactions (Malinova et al., 2021). These diagrams ensured an intuitive system design that catered to diverse users. During the prototype construction stage, a functional AR application was developed with critical features like marker-based tracking, 3D models of scout passwords, and an engaging user interface. This phase prioritized creating an interactive and gamified learning experience to improve learner retention and understanding.

Testing and feedback collection occurred during the deployment and delivery stage, where educators and learners evaluated the prototype in real-world conditions (Karrenbauer et al., 2023). Feedback led to refinements, such as improving marker sensitivity, adding progress tracking, and enhancing animations for better contextual understanding. This iterative process ensured a final product that effectively addressed user needs and enhanced learning outcomes.

The Prototype Method proved advantageous, offering close interaction with users and minimizing the risk of significant redesigns. However, challenges such as optimizing marker tracking and ensuring cross-device compatibility required careful attention. Ultimately, the application significantly improved

the learning experience for scout password recognition, transforming a static process into a dynamic, immersive activity. Future developments could integrate advanced AR features like AI-powered personalized learning and expand the application to include additional scouting skills, further enhancing its educational impact.

Use Case Diagram

Use Case diagrams to show the interaction between actors and the system. This diagram describes a complete model of what is done and who plays a role in the system, explaining the scope of activity.

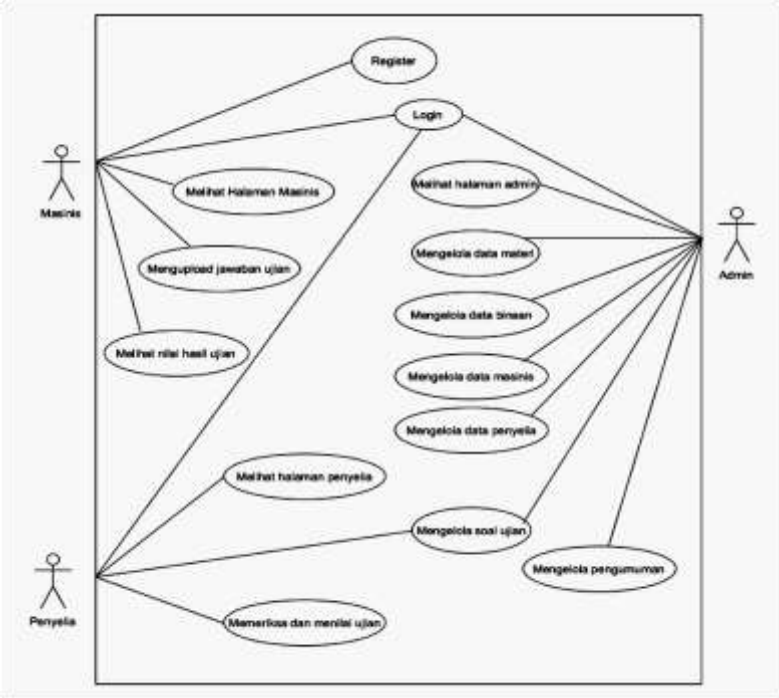

Figure 2. Use Case Diagram of Computer-Based Exam Application

Activity Diagram

An activity diagram describes the activities of system users from the entire menu in the system. The Activity Diagram below is a sequence of depictions of Computer-Based Exam Applications based on actors. If the use case diagram describes what the actor does, the activity diagram describes what activities the actor will carry out in the system to be created.

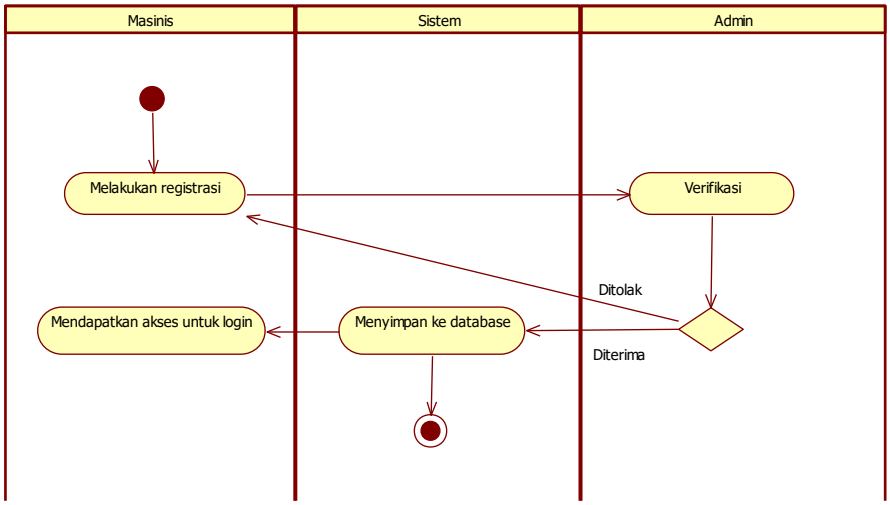

Figure 3. Activity Diagram of machinist registration

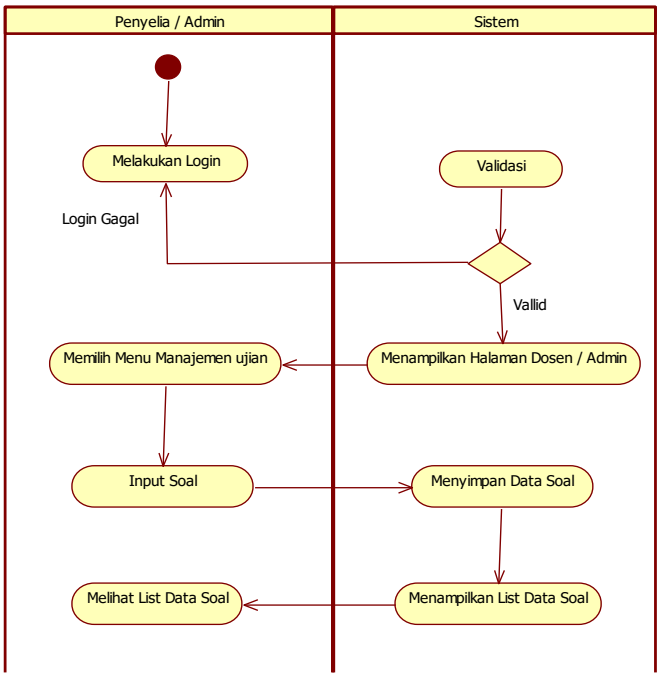

Figure 4. Activity Diagram of Question Input

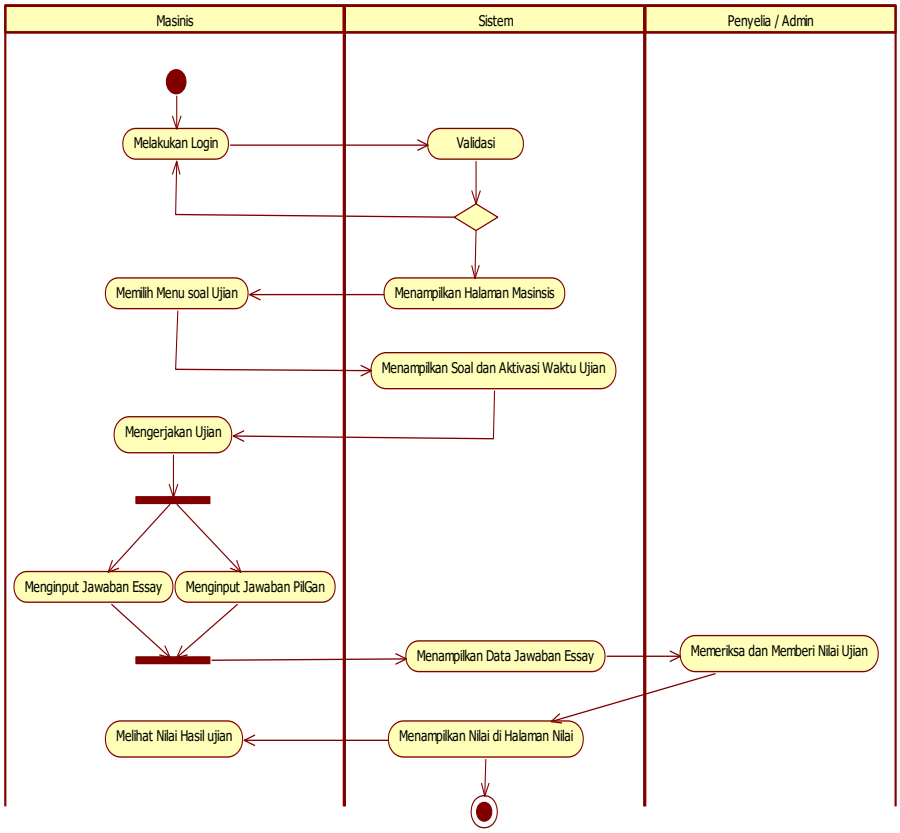

Figure 5. Online Examination Activity Diagram

The activity diagrams outline the workflows for three critical system processes: machinist registration, question input, and online examination. Each method involves distinct roles, including machinists, supervisors/admins, and the system, to ensure seamless and secure interactions.

Machinist Registration begins with the machinist submitting their details to the system. The system securely stores the data and forwards it to the admin for verification. Upon successful verification, the machinist receives login credentials, granting them access to the system. This process ensures that only authorized machinists gain access, maintaining the security and integrity of the system.

Supervisors or admins create and manage exam questions in the Question Input process. After logging into the system, the admin accesses the “Question Management” menu to add, edit, or delete questions. The system validates the inputs and securely stores the questions in the database for future exams. This structured workflow ensures that the questions are accurate, up-to-date, and ready for deployment during examinations.

The Online Examination process involves machinists accessing and taking exams via the system. After logging in, machinists are presented with the exam questions relevant to their session. The system tracks their responses in real-time, ensuring accuracy and integrity. Upon completion, the system automatically processes the results and stores the scores for admin review.

This efficient process eliminates manual grading and enhances the overall reliability of the examination system.

These activity diagrams demonstrate a well-designed, user-centric system that streamlines registration, question management, and examination processes, ensuring security, efficiency, and accuracy at every step.

Class Diagram

Class diagrams are usually used to describe tables in a database that are interrelated with one another to form a system. Several classes or objects are tables used in making the system, which can be seen from the image below:

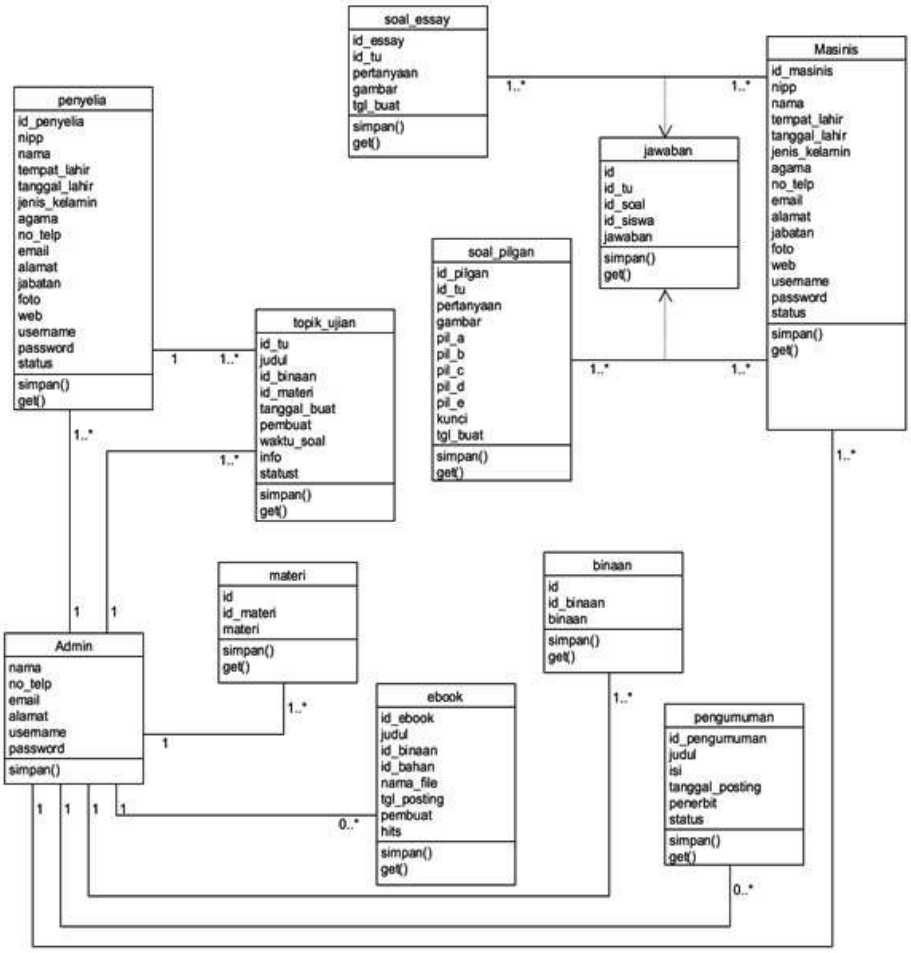

Figure 6. Class Diagram of Computer-Based Test

The class diagram provides a detailed representation of the structure and relationships within the computer-based test (CBT) system. It identifies critical entities, attributes, and connections, forming the foundation for efficiently managing machinists, exams, and related data.

The Machinist class is at the system's core, representing the primary users who take the exams. It contains attributes such as the machinist's ID, name, and account status. The machinist

interacts with various other classes, such as Ebook for accessing learning materials and Pengumuman for viewing announcements. Their exam responses are stored in the Jawaban class, which tracks answers linked to specific questions.

The Admin and Supervisor (Penyelia) classes handle the management of the system. Admins manage machinists, materials, eBooks, and announcements, while supervisors oversee exams and evaluate machinist performance. These roles ensure the smooth operation and governance of the system.

Exam questions are categorized into Soal_Pilgan (multiple-choice) and Soal_Essay (essay). These classes are connected to the Topik_Ujian class, which groups questions under specific exam topics. This structure allows for efficient question management and categorization.

The Materi, Ebook, and Pengumuman classes provide additional resources and information to machinists, enriching their learning experience. Admins upload and manage these resources, ensuring that relevant materials are available to machinists.

The class diagram demonstrates a well-structured system where machinists, supervisors, and admins interact seamlessly. The relationships between classes facilitate the management of exams, resources, and machinist data, ensuring a streamlined and scalable CBT platform.

Results and Discussion

After conducting system analysis and system design and ending with the actual creation of the program, the results achieved by the author are a Computer-Based Exam Application. In operating this application program, users must follow the provisions in the program; this application has specifications that must directly have a connection to a web server, namely Apache; this system has a main page or front page, namely the index page, which functions as an execution page to call other pages automatically when this page is accessed.

Running this computer-based Exam Application directly requires connecting to a web server, Apache. This system has a main page or front page, namely the index page, which functions as an execution page to call other pages automatically when this page is accessed.

The Login Page

This application has an opening page where the user must log in by entering the username and password that the administrator has stored; if the username and password are wrong, the page will not open, and all buttons cannot be used. The design below illustrates this administrator page.

Figure 7. Admin and Supervisor Login Page

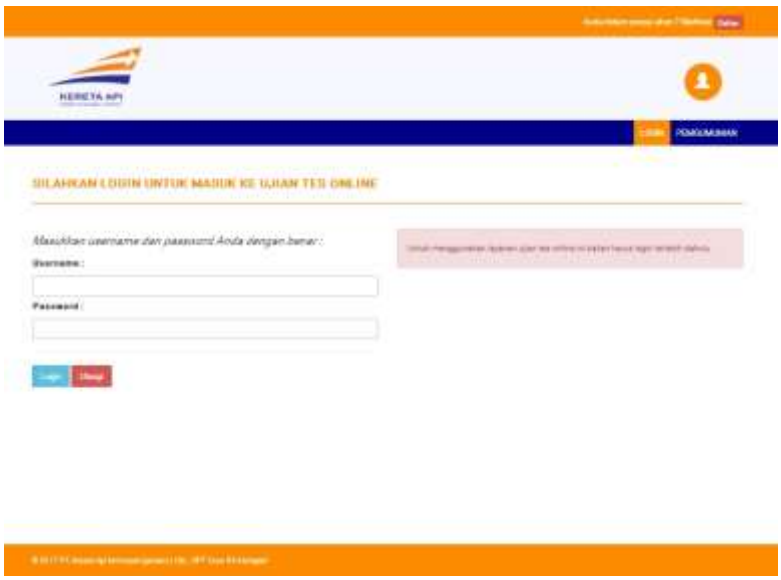

Figure 8. Machinist Login Page

Index Admin Page

The Index admin page is displayed after the user has successfully logged in as an admin user. It consists of a menu of supervisor, driver, exam, and ebook data on the dashboard. The following is the admin user index page.

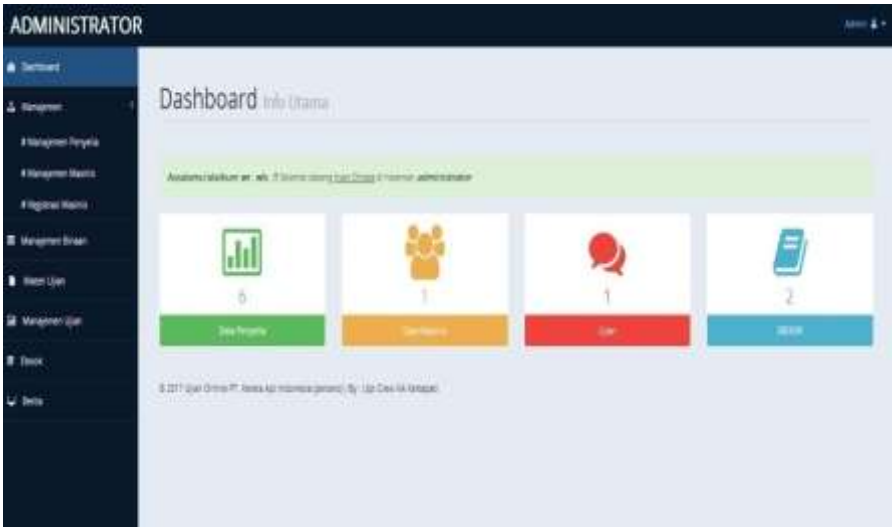

Figure 9. Index User Admin Page

Figure 10. Supervisor User Index Page

Machinist Management Page

This driver management page is displayed when the admin selects the driver management page. The admin can see the number of active and deactivated drivers from this menu from each fostered.

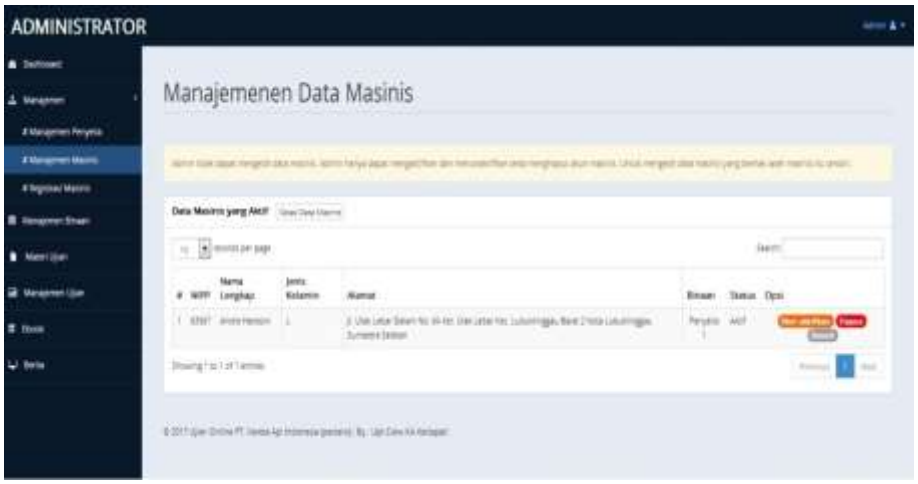

Figure 11. Masinist Management Page

Machinist Registration Page

The admin uses the driver registration page to see the number of drivers who register and activate/reject accounts.

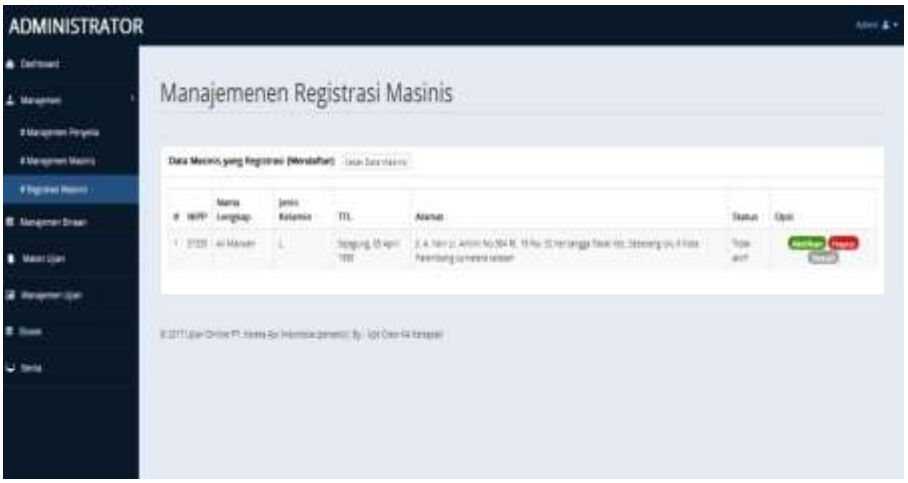

Figure 12. Masinist Registration Page

Test Page

This exam page will appear when the driver selects the exam page and takes the online exam. The driver uses this page to choose the exam material the supervisor/admin created.

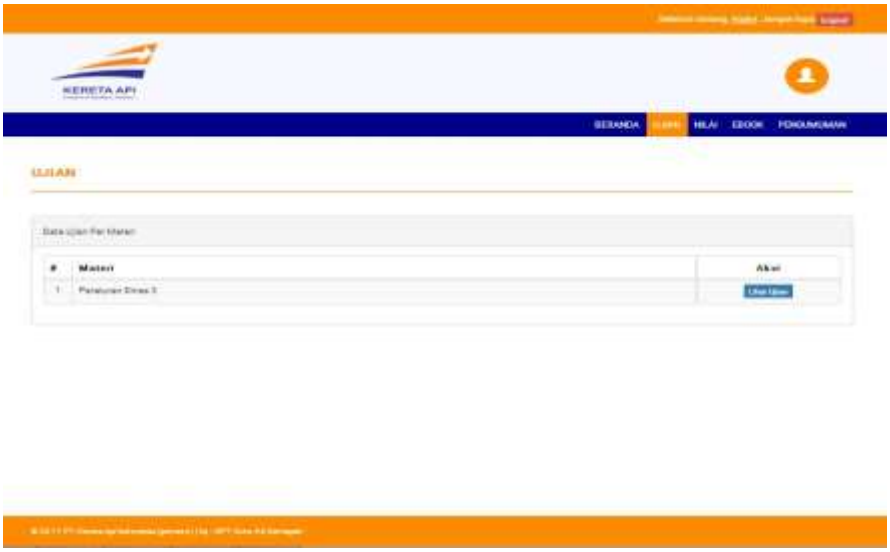

Figure 13. Test Page

Online Test Examination Page

The online test exam page is displayed after the user selects the existing test material. The following is the online test exam page.

Figure 14. Online Test Exam Page

Exam Result Score Page

Machinists can use this page to view the results of the exam that has been carried out.

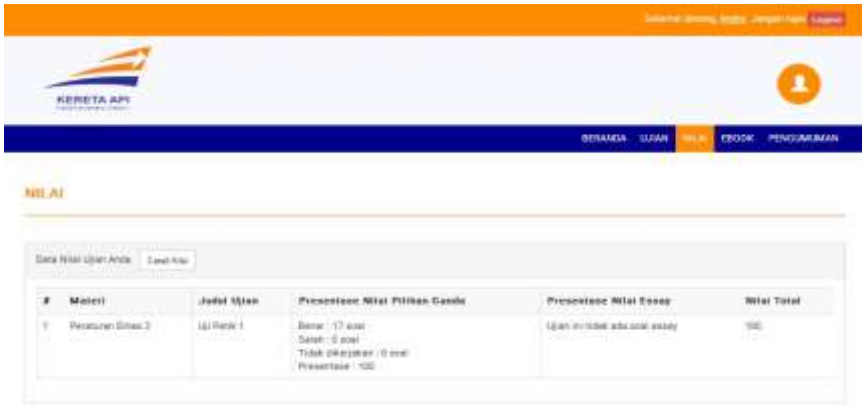

Figure 15. Exam Result Score Page

The e-Book page

This page lets the driver view ebook material that can be downloaded if the uploader (admin/supervisor) enters the ebook data.

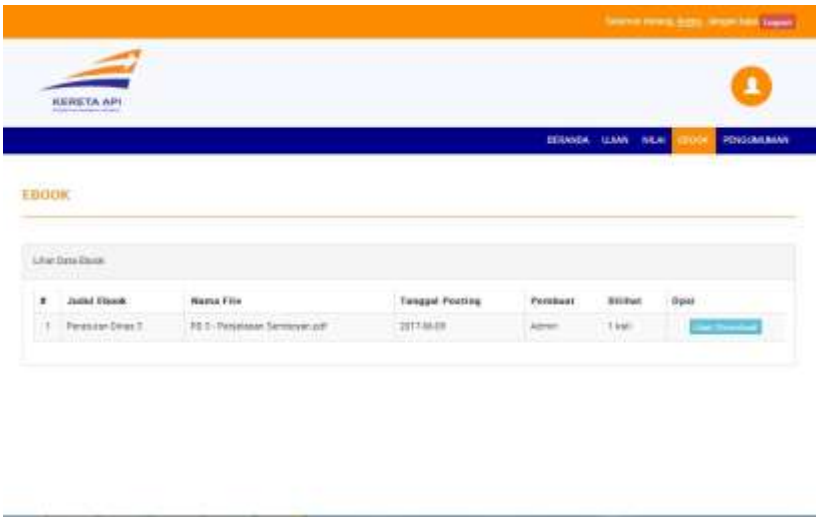

Figure 16. The e-Book Page

Announcement Page

This page allows drivers to view announcements or information made by the admin or supervisor.

Figure 17. Announcement Page

After the application development process is confirmed to be complete, the next stage is implementation and testing. This stage is more about installing the system so that End Users can understand it. This activity includes training system users and maintaining and testing the system to determine whether it is appropriate and has met user expectations.

The testing method that will be carried out in this research is the Blackbox method. This method focuses on the software's functional requirements. Blackbox testing is testing software according to functional specifications without testing the design and program code. Testing aims to determine whether the software's functions, inputs, and outputs match the required specifications.

This study tests the system's response when the user uses each menu item, as shown in Table 1.

Table 1. Result of System Test with Black Box

User	Test Class	Test Item	Test Type	Result
Admin	*Login*	Verify username and password	System	Success
	View admin index	Display the Admin index page, display the admin dashboard	System	Success
	Manage supervisor management data	View, add, edit, delete supervisor data	System	Success
	Manage driver management data	View, edit, delete, activate, deactivate driver data	System	Success
	Manage driver registration	View, approve, disapprove registration account	System	Success
	Manage supervisor data	View, edit, view driver data, delete data	System	Success
	Manage exam material management	View, add, edit, create questions, correct questions, select coaching for exam	System	Success

	Managing ebook data	View, add, delete ebook data	System	Success
	Manage news data	View, add, delete announcement data	System	Success
	Logout	End the software	System	Success
	Login	Verify username and password	System	Success
Supervisor	View supervisor index	Display supervisor index page, display supervisor profile	System	Success
	Manage mentored data	View data, edit, view drivers, delete data	System	Success
	Manage exam material management	View, add, edit, create questions, correct questions, select drivers for exams	System	Success
	Manage exam material management	View data, edit, view drivers, delete data	System	Success
Machinist	Manage ebook data	View, add, delete ebook data	System	Success
	Manage news data	View, add, delete announcement data	System	Success
	Logout	Terminate the software	System	Success
	Register	Save driver data	System	Success
	Login	Verify username and password	System	Success
	View driver index	Display welcome	System	Success
	View profile data	Display and edit profile	System	Success
	Take an online test exam	Display online exam questions data	System	Success
	View the score page	Display the results of exams that have been taken by machinists	System	Success
	View the ebook page	Display data and ebook files	System	Success
	View the announcement page	Display announcement data	System	Success
	Logout	Terminate the software	System	Success

Based on Table 1, the system underwent comprehensive testing for its core functionalities across three user roles: Admin, Supervisor, and Machinist (Driver). The testing results demonstrated consistent success, indicating high reliability and usability. For the Admin role, critical functionalities such as secure login, supervisor and driver data management, approval of driver registrations, and resource handling (ebooks and announcements) were effectively executed. Additionally, the Admin's ability to manage exam material—including creating, editing, and assigning questions—showcased a robust feature set that supports dynamic administrative needs.

For Supervisors, the system provided essential tools to manage their roles effectively. Successful login and access to a personalized dashboard were confirmed, along with functionalities

like editing mentored driver data and participating in exam material management. The ability to interact directly with machinists by assigning exam questions and managing their progress highlights the system's support for interactive supervision.

The Machinist role primarily focused on resource access, assessments, and profile management. Features such as online exam participation, viewing exam results, and accessing ebooks and announcements worked seamlessly, reflecting the system's user-friendly design. Secure registration and login further emphasized a smooth and secure user experience for machinists. Moreover, the logout functionality worked consistently across all roles, ensuring secure session termination and safeguarding user data.

Overall, the system demonstrates robust role-specific customization and reliability. The testing confirmed a well-defined role-based access control mechanism, providing each user group access to relevant features without overlap. While the system is already robust, enhancements such as automated testing for scalability, integration of analytics for user activity insights, and accessibility improvements can elevate its functionality further. Including additional security measures, like multi-factor authentication, would strengthen protection against unauthorized access. In conclusion, the system is a well-rounded, efficient platform capable of supporting diverse educational and training needs with room for future scalability and innovation.

Conclusion

This study highlights the successful integration of Augmented Reality (AR) technology in developing an interactive learning media for scout password recognition. By leveraging marker-based AR tracking, the application offers a dynamic and immersive learning experience, addressing the limitations of traditional teaching methods. The gamified approach enhances engagement and facilitates better comprehension and retention of knowledge.

Implementing the Prototype Method ensured a user-centric development process, incorporating iterative feedback to refine the application. Using UML tools, such as Use Case and Activity Diagrams, contributed to an intuitive and structured system design. Comprehensive testing using the Blackbox method validated the application's functionality, demonstrating its effectiveness and reliability.

Key features, including interactive 3D models, gamification, and progress tracking, create a personalized and engaging learning environment. Additionally, the system's accessibility on standard mobile devices ensures widespread usability, eliminating the need for specialized hardware.

The application's success demonstrates the potential of AR technology in transforming niche educational contexts, such as scouting activities, into more interactive and compelling learning experiences. This research provides a framework for future advancements in educational technology, emphasizing the importance of innovation in addressing diverse learning challenges. Future developments could explore integrating AI for personalized learning and expanding the application to include additional scouting skills, further enriching the educational landscape.

Through this initiative, the study advances scouting education and underscores the broader applicability of AR as a transformative tool in various educational domains.

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