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Revolutionizing Aviation Education: Integrating Virtual Reality into Runway Light Prototype Development at Makassar Aviation Polytechnic

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This research endeavors to design, develop, and test a Virtual Reality (VR) runway light application prototype as a practicum tool at Makassar Aviation Polytechnic. The primary objective of this application is to overcome the limitations of existing runway light practice tools, which are currently only accessible in a restricted area of Sultan Hasanuddin Airport. The research methodology employed is Research and Development (R&D), specifically the 4D development model, comprising Define, Design, Develop, and Disseminate stages. A needs analysis was conducted during the define stage through a comprehensive literature review, observation, and interviews with lecturers

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and students. The design stage involved designing the user interface and application structure, whereas the development stage entailed creating 3D models of runway light equipment and developing interactive features of the application. The disseminate stage comprised testing the application with students and distributing usage guides. The development results indicate that the VR runway light application successfully created a realistic and interactive simulation environment. The pilot test revealed that 83.33% of students "strongly agreed" and 16.67% "agreed" regarding the ease of use aspect. In terms of movement accuracy, 45.83% of students "strongly agreed," 41.67% "agreed," and 12.5% "moderately agreed." Furthermore, 66.66% of students "strongly agreed," 16.67% "agreed," and 16.67% "moderately agreed" that the application increased their competence. This study concludes that the VR runway light application is an effective practicum aid, enhancing students' understanding and skills in installing and dismantling runway light equipment. Recommendations for future development include improving movement accuracy, incorporating additional interactive features, and testing the application in other educational institutions to further validate its effectiveness.

Keywords: Virtual reality; runway light; learning media; application development.

1. INTRODUCTION

Virtual Reality (VR) technology has progressed rapidly in recent years. VR is used in the entertainment industry and has also penetrated various sectors, such as healthcare, military, architecture, and education [1,2]. VR's ability to create near-reality simulated environments makes it a handy tool for different practical applications [3,4].

Virtual Reality has started to be used as a practical learning medium in the field of education [5,6,7]. The technology allows students to learn in an immersive and interactive environment, increasing understanding and retention of the material learned [8,9]. VR also enables simulation of real situations that are difficult or even dangerous to do in the real world so students can learn safely and effectively [10,11,12].

Runway light is one of the critical subjects in the Landing Aids course in the Airport Technology Study Program at Makassar Aviation Polytechnic. Runway lights are a visual guide for pilots when landing aircraft, especially in bad weather or at night. Therefore, a deep and practical understanding of runway lights is crucial for students learning about Landing Aids.

However, several problems in practicum activities related to runway lights at Makassar Aviation Polytechnic exist. Currently, the polytechnic needs to have adequate runway light practice tools. To practice optimally, students must go to Sultan Hasanuddin Airport. Unfortunately, the runway light equipment is located on the airside, which is a restricted area, so access to practice is very limited and cannot be done optimally.

To overcome this problem, the researcher wants to develop a Virtual Reality application to help students conduct runway light equipment practicum activities. This application will allow students to explore and simulate the virtual disassembly of runway light equipment. Thus, students can improve their motor skills and gain better practical experience without physically being at the airport.

The development of this Virtual Reality prototype application is expected to provide several benefits. Students can learn and practice more flexibly and safely without time and place restrictions [13,14]. In addition, using VR can also increase student interest and motivation [15]. Hopefully, this application can be an effective and efficient learning tool for improving student competence in airport technology [16].

2. METHODS

The research method used to develop this Virtual Reality-based runway light prototype is the Research and Development (R&D) method. This method was chosen because it aims to develop products that can be applied in a natural environment and test the effectiveness and validity of these products [17].

The development model used in this research is the 4D model, which consists of four main stages: Define, Design, Develop, and Disseminate. This model was chosen because it provides a systematic framework for developing innovative education and learning products [18].
The first stage is Define. At this stage, identification and analysis of the need to develop Virtual Reality runway light applications are

carried out. Activities include literature review, observation, and interviews with lecturers and students at Makassar Aviation Polytechnic. The goal is to deeply understand the problems faced in the runway light practicum and determine the application specifications that need to be developed.

The second stage is Design. At this stage, the concept and structure of the Virtual Reality runway light application are designed. The Design includes designing the user interface, navigation flow, and features that will be included in the application. An initial prototype of the application design is also made to get initial feedback from potential users and stakeholders.

The third stage is Develop. In this stage, application development is carried out based on the Design that has been made. The development includes creating 3D models of runway light equipment, coding the application's interactions, and integrating with VR devices. After the application has been developed, internal testing is carried out to ensure that all features function properly and that the application runs according to the Design.

The fourth stage is Disseminate. At this stage, the application that has been developed is disseminated to students and lecturers at Makassar Aviation Polytechnic. Dissemination activities include training on the use of the application, dissemination of usage guides, and collection of feedback from users for further improvement. In addition, the application was presented at seminars and conferences to get input from the wider academic community.

Here is a figure of the stages of the 4D development model:

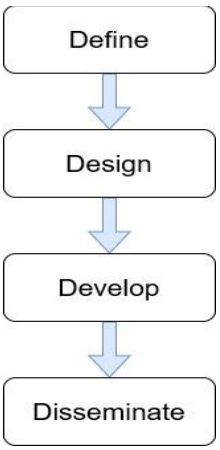


Fig. 1. 4D development model

Here is the design of the Runway Light Virtual Reality program:

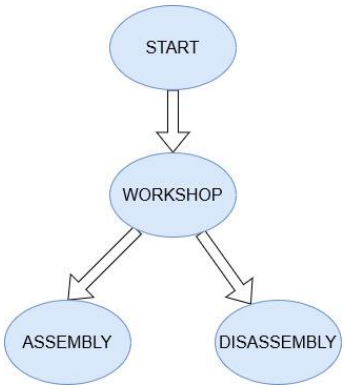


Fig. 2. Runway light virtual program design

The program design of the Virtual Reality runway light application begins with a "start" display. Users can then select the workshop menu, where they can choose between two options: "assembly" or "disassembly." The "assembly" option allows users to learn how to assemble the runway light equipment, while the "disassembly" option allows users to learn how to disassemble it.

The following is the Activity Diagram of Virtual Reality PAPI Light:

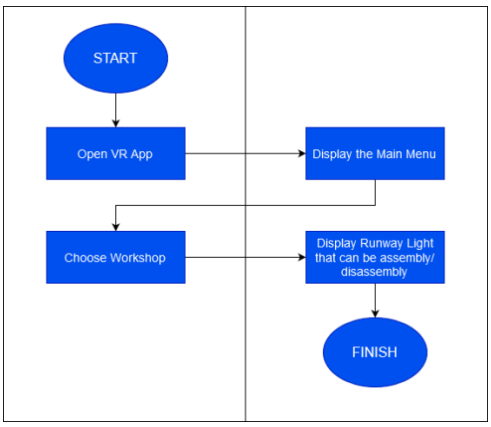


Fig. 3. Activity diagram virtual reality runway light

The activity diagram of the Virtual Reality runway light application illustrates the flow of user activity in the application. This diagram starts with the "start" activity and opens the application. Once the application is opened, it will display the main menu. Then, the user will select the workshop menu; the application will display the runway light workshop room.

3. RESULTS AND DISCUSSION

3.1 Runway Light Virtual Reality Prototype App Development

The results of developing the Virtual Reality runway light application prototype show that this application successfully creates a realistic and interactive simulation environment for practicum activities. The application allows users to simulate the installation and disassembly of runway light equipment virtually. 3D models of runway light equipment have been created with accurate details, and user interaction with the application runs smoothly.

3.2 Implementation Result of Virtual Reality Runway Light

The results of implementing the Virtual Reality runway light application show that this application can run well on the VR device. This application utilizes VR technology to provide an immersive experience where users can interact directly with the 3D runway light model. Users can feel the sensation as if they are in a real airport environment, which helps improve their understanding of the function and workings of the runway light equipment. In addition, the app also comes with an interactive guide that assists users in every stage of equipment installation and disassembly.

a. Home App Display

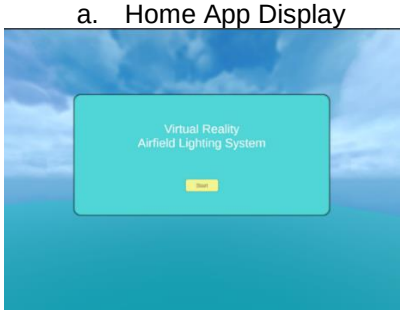


Fig. 4. Home app display

On this screen, the user is greeted with the initial view of the app, which presents the option to "start."

b. Main Menu Display

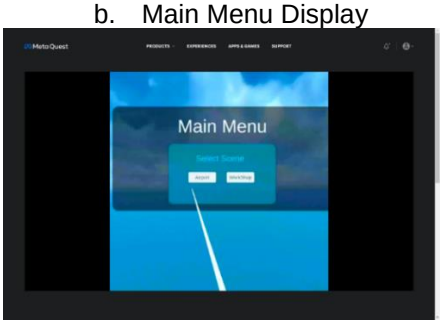
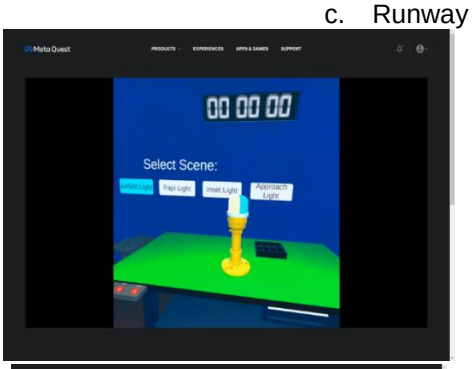
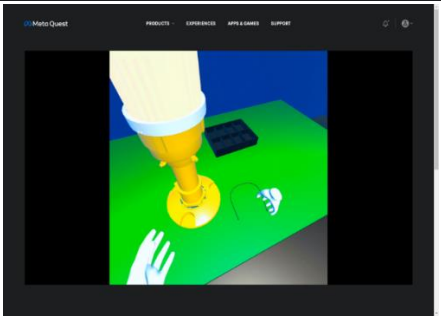


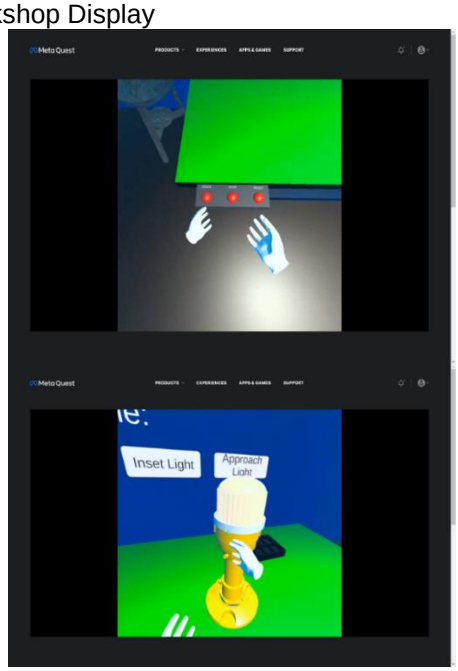
Fig. 5. Main menu display

In this display, the user can choose between the "workshop" option to simulate a runway light workshop and "airport" to surf the airport virtually in the main menu.

c. Runway Light Workshop Display







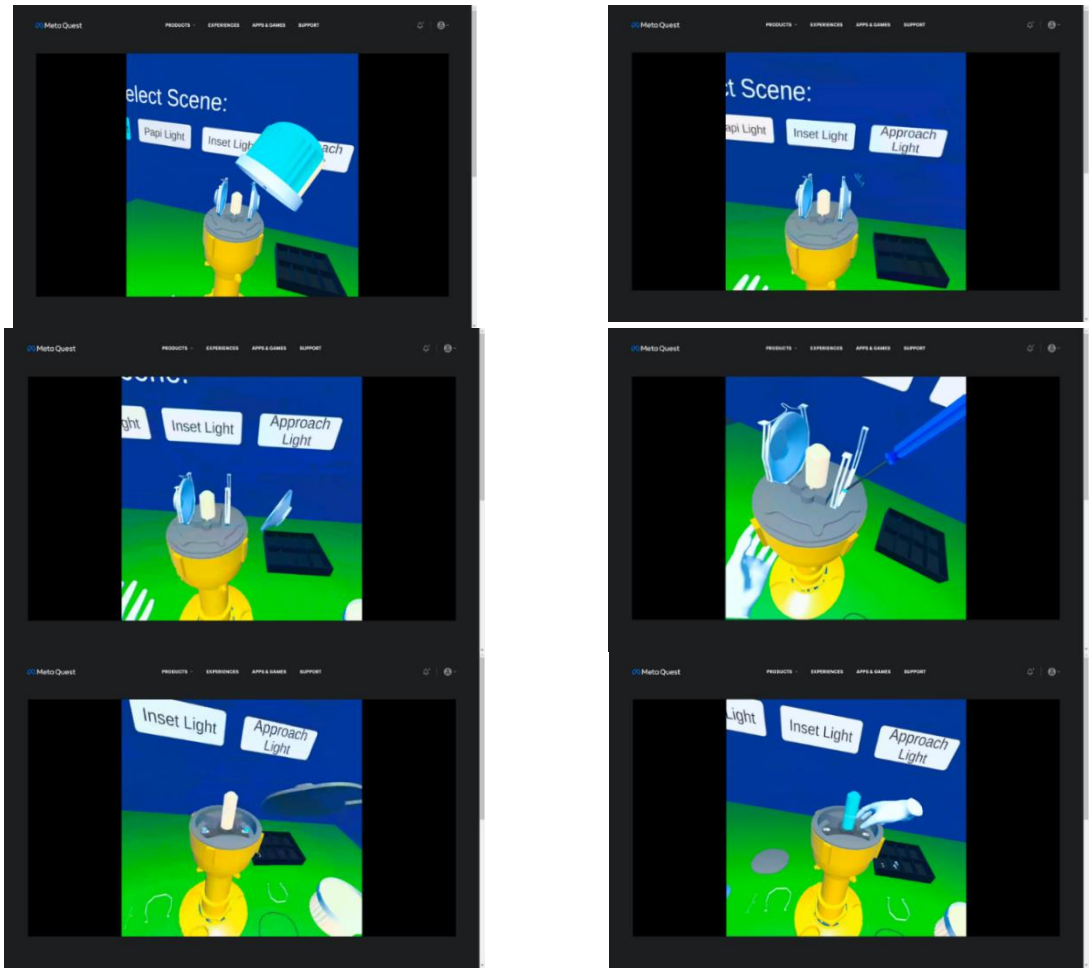


Fig. 6. Runway light workshop display

Displays a virtual workshop environment where users can interact with the runway light equipment. In this view, users can view 3D models of the equipment and follow step-by-step instructions for installation or disassembly. The view is also equipped with zoom and rotation features to provide a more detailed view.

3.3 Black Box Testing

The black box testing results show that the application runs well and by the expected functionality [19]. Testing focused on user interaction, including menu selection, 3D model manipulation, and application response to user input. The test results show that all application features function properly without significant bugs or errors.

Questioner: In this study, questionnaires were used as an evaluation tool to collect feedback from students regarding the use of Virtual Reality runway light applications. The purpose of this questionnaire is to measure the extent to which this application meets the expectations and needs of users in the aspects of ease of use, accuracy of movement, and increased competence. Through this questionnaire, researchers can obtain useful empirical data to assess the effectiveness and efficiency of the application, as well as to identify areas that require further improvement.

This questionnaire was filled out by 24 students from the Airport Technology Study Program at Makassar Aviation Polytechnic. The selection of respondents was carried out randomly, but it was ensured that they had all used the Virtual Reality runway light application in their practicum activities. This questionnaire consists of three main sections, each of which focuses on the following aspects:

Table 1. Black box testing result

No	Testing Activities	Expected Results	Test Results	Conclusion
1	Powering on and running the Oculus device	Oculus device can run properly	Oculus device can run properly	Test Succesful
2	Running the PAPI Light app on an Oculus device	The application runs well on Oculus devices	The application runs well on Oculus devices	Test Succesful
3	After pressing the "start" button, the main menu display will appear.	The main menu will appear with "Airport" and "Workshop" options.	The main menu will appear with "Airport" and "Workshop" options.	Test Succesful
4	Select the "Workshop" menu in the main menu screen	The workshop simulation display will appear	The workshop simulation display will appear	Test Succesful
5	Set the work timer	When pressing the "Start" button, the time will run, the "stop" button will stop, and the "reset" button will return to the beginning.	When pressing the "Start" button, the time will run, the "stop" button will stop, and the "reset" button will return to the beginning.	Test Succesful
6	Picking up tools	The selected tool will be picked up when picking up a tool in the holder.	The selected tool will be picked up when picking up a tool in the holder.	Test Succesful
7	Releasing the spring latch	The spring latch will release	The spring latch will release	Test Succesful
8	Removing the lamp dome hoop	The lamp dome hoop can be removed	The lamp dome hoop can be removed	Test Succesful
9	Removing the lamp dome glass	The lamp dome glass can be removed	The lamp dome glass can be removed	Test Succesful
10	Removing the cable lock	The cable lock can be removed	The cable lock can be removed	Test Succesful
11	Removing the lens	The lens can be removed	The lens can be removed	Test Succesful
12	Removing the bolt with a screwdriver	The bolt can be removed	The bolt can be removed	Test Succesful
13	Removing the lens mount	The lens mount can be removed	The lens mount can be removed	Test Succesful
14	Removing the lamp	The lamp can be removed	The lamp can be removed	Test Succesful

Ease of use: Ease of use is one of the important aspects measured through questionnaires in this study. The questionnaire results show that most students rate the Virtual Reality runway light application as easy to use. The user interface is intuitively designed so students can quickly understand how to navigate the application. The instructions provided in the application are also considered clear and assist users in following each step of the simulation of the installation and disassembly of runway light equipment. Features such as well-structured menus and informative icons created a positive user experience. Overall, students felt comfortable and experienced no significant difficulties using the app for their practicum activities.

The questionnaire results regarding the ease-of-use aspect show that most students find this application very easy to use. 83.33% of respondents stated "strongly agree" that this application has an intuitive and easy-to-understand interface. This reflects that the application design successfully meets user expectations. The remaining 16.67% of respondents "agreed" with the statement. All of the respondents found the app easy to use,

indicating that in terms of ease of use, the app has been designed very well and adequately.

Movement accuracy: Movement accuracy is a key factor in creating a realistic simulation experience. The questionnaire results indicated that students felt that the app successfully replicated the movement of the runway light equipment very well. Accurate and responsive simulation allows users to experience close to real conditions. The object movements and manipulations performed in this application were very precise, allowing students to understand how the runway light equipment works more realistically. This accuracy improves the quality of learning and increases students' confidence in handling the actual equipment.

Students' opinions were more mixed regarding movement accuracy but still showed positive results. A total of 45.83% of respondents stated "strongly agree" that the app can accurately and realistically replicate the movement of runway light equipment. Meanwhile, 41.67% of respondents "agreed" with the accuracy of the movements displayed in the app. Only 12.5% of respondents stated "moderately agree," which means there is still room for improvement. Nonetheless, most respondents agreed that the app provides a fairly realistic simulation experience close to real conditions.

Competency improvement: Competency improvement is the main goal of developing this Virtual Reality runway light application. Based on the questionnaire results, students felt that using this application significantly helped them understand the concepts and procedures related to runway lights. The app allows students to practice independently in a safe and controlled environment, improving their understanding and skills. Students reported that they felt more prepared and confident in performing the installation and dismantling of runway light equipment after using the app. This increase in competence demonstrates that this VR application is effective as a practicum learning aid, providing significant added value to airport technology education at Makassar Aviation Polytechnic.

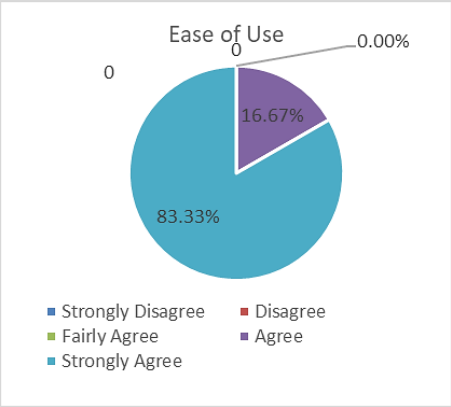


Fig. 7. The questionnaire results

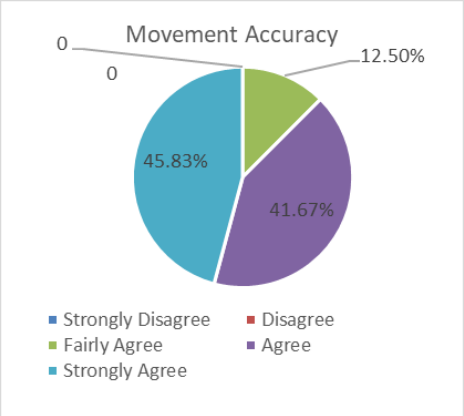


Fig. 8. Movement accuracy chart

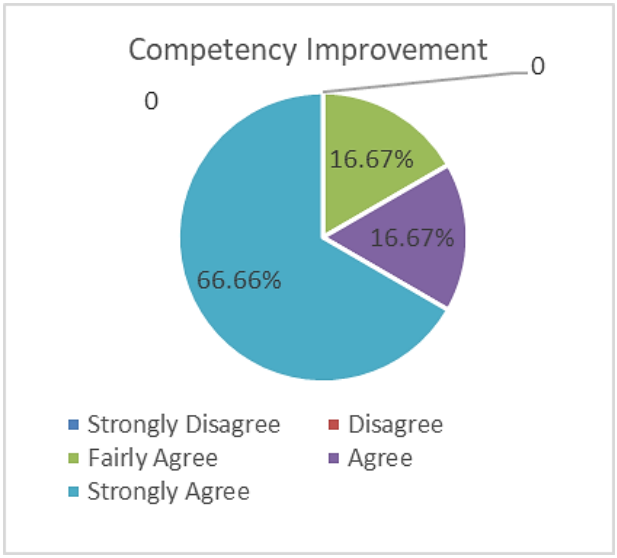


Fig. 9. Competency improvement chart

In improving competency, most students feel significant benefits from using this application. 66.66% of respondents stated "strongly agree" that this Virtual Reality runway light application helped them understand the material and improve their practical skills. In addition, 16.67% of respondents stated "agree," and another 16.67% stated "moderately agree" with the statement. This shows that this application has successfully achieved its main goal, improving students' competence in runway light technology. However, a small percentage feel that the improvement effect still needs to be improved.

Overall, this questionnaire chart shows that students receive the Virtual Reality runway light application well and are successful in ease of use, accuracy of movement, and increased competence. These results provide empirical evidence that this application is an effective tool in practicum learning at Makassar Aviation Polytechnic.

4. CONCLUSION

Based on the research and development results of the Virtual Reality runway light application prototype, this application successfully creates a realistic and interactive simulation environment for practicum activities at Makassar Aviation Polytechnic. This application provides a practical solution to existing practical tools' limitations, allowing students to learn and practice more flexibly and safely. Questionnaire results showed that most students found the application easy to use, had accurate movements, and effectively improved their competence in the installation and disassembly of runway light equipment. Thus, the app succeeded in achieving its main objective as an innovative and effective learning aid.

For further development, it is recommended that this Virtual Reality runway light application continues to be refined based on user feedback. Some aspects that can be improved include the accuracy of movement and adding more detailed interactive features. In addition, it is necessary to conduct intensive training for lecturers and students so that they can utilize this application optimally. It is also recommended to conduct trials in other educational institutions to gain a broader perspective and ensure that this application can be effectively applied in various educational environments. Thus, this application is expected to make a greater contribution to improving the quality of education in the field of aviation technology.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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