Development Study of Augmented Reality Based Learning Media Very High Frequency Omni-Directional Range (VOR) at Aviation Polytechnic

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ABSTRACT

This research aims to develop Augmented Reality (AR) based learning media for Very High Frequency Omni-Directional Range (VOR) course at Aviation Polytechnic. VOR is an important navigation aid in aviation, which requires in-depth understanding and adequate practice by students. However, limitations in the provision of interactive teaching aids and simulations pose a challenge in the learning process. Therefore, this research proposes the use of AR technology to overcome these obstacles. This research method includes the stages of needs analysis, design, development, implementation, and evaluation. In the needs analysis stage, surveys and interviews with lecturers and students were conducted to identify specific needs in VOR learning. Next, AR learning media was designed and developed using Unity and Vuforia software. This media was then implemented in class and trialled on a group of students. The results showed that the use of AR in VOR learning improved students' conceptual understanding and practical skills. Evaluation was conducted through pre and post tests on experimental and control groups, as well as student satisfaction questionnaires. The data obtained were analysed using statistical tests to assess the effectiveness of the developed learning media. The analysis results showed a significant increase in the understanding and skills of students using AR media compared to conventional methods. The conclusion of this study is that AR-based learning media is effective in improving the quality of VOR learning at Aviation Polytechnic. The use of AR technology not only makes the learning process more interactive and engaging, but also provides an immersive and realistic learning experience. Recommendations for future research include the development of additional features in AR media and the application of this technology to other courses that require complex understanding and practical interaction.

Keywords: *Augmented Reality (AR), Very High Frequency Omni-Directional Range (VOR), Learning Media Aviation Polytechnic Navigation, Aids Learning, Innovation Learning, Effectiveness*

1. INTRODUCTION

Politeknik Penerbangan Makassar, hereinafter referred to as Poltekbang Makassar, is a vocational education institution under the auspices of the Department of Transportation [1], especially Air Transportation. In the decision of the director of Vocational Education it is stated that vocational education is directed to produce skilled and superior graduates according to the needs of the industrial world and the world of work (IDUKA), from this statement to achieve a skilled predicate for vocational education graduates [2], it is necessary to be equipped with certain knowledge and skills. according to their field. Jumadin (2020) The quality of vocational learning is seen from the quality of the cognitive domain measured based on basic automotive courses in the good category, seen from the quality of the effective domain measured based on attitudes, interests, values, self-concept, and morals in the good category, and the quality of the psychomotor domain in the form of skills carried out physically in the laboratory in the very good category [3]. From these results the quality of the effective domain of output is categorized as good, while for psychomotor quality it is categorized as very good [4].

The task of educational institutions is inseparable from the use of Curriculum and Syllabus, hereinafter referred to as Kursil. Monitoring of the implementation of the Curriculum is carried out once every 5 years to

A. Kusumastuti et al. (eds.), *Proceedings of the 6th Vocational Education International Conference (VEIC 2024)*,
Advances in Social Science, Education and Humanities Research 896, https://doi.org/10.2991/978-2-38476-342-9_11

ensure that the Curriculum is in accordance with market needs and scientific developments [5], in the curriculum includes theoretical and practical learning, where the composition of the two lessons is 40% of the number of hours of theory and 60% of the number of hours of practice.

40% of the total number of hours of theory and 60% of the total number of hours of practice. This monitoring is carried out by the Air Transportation Human Development Center, hereinafter referred to as PPSDMPU [6]. In making this course, it involves stakeholders (AIRNAV Indonesia, ANGKASA PURA I, ANGKASA PURA II), academics, and the regulator in this case is the Directorate of Flight Navigation, hereinafter referred to as Dirnavpen [7].

Makassar aviation polytechnic as a technical implementation unit of the Civil Aviation Human Resources Development Center, is trusted to organize Vocational education with several study programs, namely: Diploma III Air Navigation Technology abbreviated as D.III TNU, Diploma III Airport Technology abbreviated as D.III TBU, Diploma III Aircraft Maintenance Technology abbreviated as D.III TPPU, Diploma III Air Traffic Management abbreviated as D.III MLLU [8].The scope of the dissertation is on the diploma III Air Navigation Technology study program, where this study program was formed to prepare ready-to-use and reliable technicians in carrying out maintenance, operating, and maintaining aircraft [9].

Very high frequency Omni Range equipment hereinafter referred to as VOR is air navigation equipment, functioning to provide direction information to aircraft against an airport with a certain azimuth from 0 (zero) degrees to 360 degrees in the form of visual displays [10]. VOR equipment works in the frequency range from 108 MHz - 118 MHz. The frequency used by navigation equipment for Makassar Sultan Hasanuddin International Airport is 114.7 MHz. VOR equipment works for a full 24 hours, so the equipment consists of two units where both function with Main and Stanby status. In accordance with the rules regarding the placement of navigation aids equipment, it is at 3 Km from the end of the runway and is on the runway center line with a building height of 3 meters, width of 6 meters and length of 6 meters at the airport [11]. To be used as a practicum tool, the VOR equipment with operational equipment status where the equipment works 24 hours, cannot be maximally used as a learning media tool because the equipment must not occur operational failure because it will endanger flight safety [12]. The results of observations or initial observations of the implementation of practical learning of navigation aids courses, found that the duration of learning time is not effective, practicum activities are not effective, each student in receiving lessons from lecturers is not the same, the emergence of unfocusedness [13].

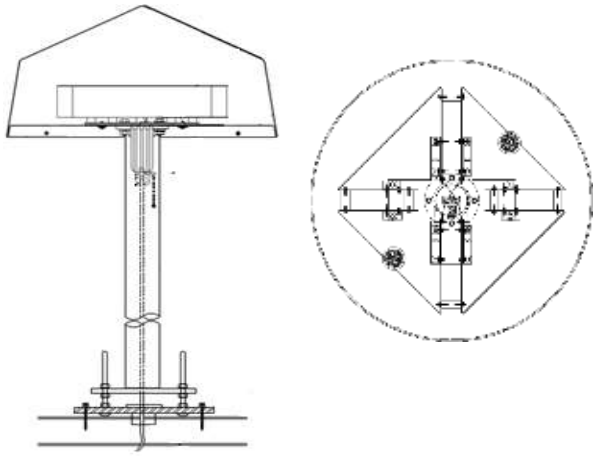

Figure 1 Sideband Antenna Shape

Based on the results of preliminary observations, it can be concluded that the use of VOR equipment as one of the facilities in supporting KBM, it will reduce cadets in absorbing knowledge in basic navigation aids so that the CPMK of the course is not achieved, as well as having an impact on the CPMK in the curriculum which requires cadets after completing the KBM process to be able to explain the working principles and perform maintenance, operation and maintenance as well as analyze damage and completion on navigation equipment is not achieved, so it is deemed necessary to make a basic laboratory of navigation aids in the form of three-dimensional media [14].

Figure 2 Cone of Experience

Virtual Reality (VR) is a technology capable of creating simulations. This simulation can be similar to the real world; Virtual Reality or VR is a technology that is able to evoke a real 3D atmosphere, making users feel like they are in the real world even though the simulation in front of them is a virtual world [15]. Learning media produces communication between educators and students in the learning process. If the learning process does not use the media, the learning process will occur [16]. The implementation of educational media using Augmented reality can stimulate the mindset of cadets to think critically about problems and events that exist in

everyday life because the nature of educational media is to assist cadets in the learning process with the presence or absence of teachers in the educational process [17], so that the use of augmented education media with reality can directly provide learning wherever and whenever the learner wants to carry out the learning process [18]. This technology can be applied to maximize the KBM of air navigation aids courses in the Air Navigation Technology study program.

2. METHODOLOGY

The type of research used is Research and Development (R&D). The Research and Development method or called research and development is a research method used to produce products and test the validity, practicality, and effectiveness of the product. This research will be conducted using the 4D Model development [19], namely (1) defining, (2) planning, (3) developing, (4) disseminating. This research is expected to produce learning device products in the form of AR media that are valid, practical and effective. The subjects in this study were the lecturer of the Basic Air Navigation Aids course and 24 cadets in the Air Navigation Technology study program, and the object was learning multimedia. as for the research subjects needed include: one to one trials of 3 people, small group trials of 5 people, and field trials of 16 people, a total of 24 cadets [20].

Data collection in this study was carried out in several ways, according to Sugiono (2017): The quality of the instrument determines the quality of the data collected later. To get a good instrument and obtain information about the validity, practicality, and effectiveness of AR Media, the researcher uses an instrument.

Table 1. Instrument Grid

Aspects	Statement	Number of items
A. Elemen Visual	1. Appropriateness of selecting components in the media	2
	2. Accuracy of the component objects used	2
	3. Color harmony of components with background	2
B. Elemen Verbal	4. Appropriateness of font usage	2
	5. Appropriateness of font color	3
	6. Appropriate use of font size	2
	7. Correct use of capital letters	1
	8. Spacing between letters	2
	9. Readability of the text	1
C. Design Pattern	10. Accuracy of the number of objects in one media page	1
	11. The simplicity of the text or images on the media page	1
	12. Layout arrangement in media display	1
	13. Clarity of instructions for use	1
Number of items		21

The data analysis technique in this study is to use descriptive percentage analysis which disseminates the development results, validator responses, one to one trial results, small group trials and large group trials. This type of data analysis is described in more detail to answer each research question.

Practicality data analysis is obtained by considering learner response data obtained from cadet response questionnaires. To state the practicality of the learning model product developed, it was analyzed descriptively with modified criteria.

Table 2. usability assessment category

Percentage result	Eligibility criteria
0% - 20%	Very less feasible
21% - 40%	Less feasible
41% - 60%	Decent enough
61% - 80%	Worth
81% - 100%	Very feasible

The instrument's validity aims to determine whether the instrument is suitable for practicality. Instrument validation is analyzed descriptively in the form of giving an assessment, which is expressed with four assessment categories: very valid, quite valid, less valid, or invalid.

Test sheets in the form of pretests and posttests given to cadets to measure the success of the implementation developed will be analyzed descriptively by showing the value of cadets before and after implementation. This can be done using the N-Gain formula as follows:

$$N\text{-}Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimum - \text{Skor Pretest}} \quad (1)$$

The calculation results are interpreted using normalized gain according to the classification of () as follows:

Table 3. N-Gain Score Acquisition Category

Limitations	Category
$g > 0{,}7$	High
$0{,}3 < g \leq 0{,}7$	Medium
$g \leq 0{,}3$	Low

3. RESULTS AND DISCUSSION

Based on the table above, using the formula X = 1-A / B then X = 0/12 and the result obtained is 1, it can be concluded that the results of testing the functionality aspects of Augmented reality Very Hight Frequensy are declared good.

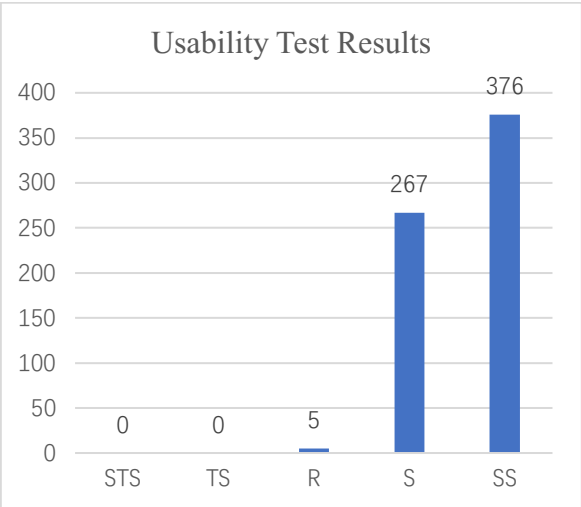

Figure 3 Graph of Usability Test Results

The results of questionnaires and questionnaires distributed obtained the results that from the usefulness indicator obtained a score of 92.6% which entered the criteria very feasible which proves that this system helps me to be more effective, productive, this system is useful, this system helps me with the tasks I do, this system makes the things I want to achieve easier to do, this system saves me time when using it, this system suits my needs, this system works according to what I expect.

The ease of use aspect can be concluded with a score of 91.25 that this system is easy and practical to use, this system is easy for users to understand, the operating steps of this system are not complicated, this system can be adjusted according to needs, using this system is easy / no need to struggle, this system can be used without written instructions, the system is not found inconsistencies during its use, high level users (teachers) and ordinary (students) will like this system.

The ease of learning aspect obtained the results of 90.63% which entered the very feasible zone shows that cadets can overcome mistakes quickly and easily in using this program, this program can be used smoothly at any time, this program can be used quickly, the use of this program can be remembered quickly, this program is easy to learn to use, cadets can quickly become skilled in using this system.

Figure 4 Media Start View

The interface design of Augmented reality (AR)-based navigation aids learning media application should be designed by considering ease of use and effectiveness in delivering the material. When users first open the application, they will be greeted by an opening screen displaying the application logo and several illustrations depicting AR technology in the context of flight navigation. Once past the opening screen, users will be directed to the intuitive main home screen. At the top of the screen is the main navigation menu with options such as "Home," "Learning Materials," "AR Practice," "Profile," and "Settings." This menu design allows users to access the app's various features easily. The "Learning Materials" section provides learning modules divided into chapters, such as "Introduction to Aviation Navigation," "Navigation Aids System," and "Operation Techniques of Navigation Aids." Each module is presented in a rich multimedia format, including text, images, videos, and 3D animations. For a more interactive experience, the "AR Practice" section allows users to utilize their device's camera to activate AR simulations. When the user points the camera at a specific marker or object, 3D models of navigation aids such as VOR (VHF Omnidirectional Range) or ILS (Instrument Landing System) will appear in real-time.

Based on the media that has been designed by researchers at the design stage, the next stage is to carry out the development stage by looking at the responses of validators / experts from the designs that have been made, namely media feasibility and material feasibility as well as the feasibility of instruments and questions for cadets / students. The media feasibility test will provide an assessment of the augmented reality-based VOR navigation aids media, the material feasibility test will provide an assessment of the learning module which contains the work steps for implementing the practice of VOR navigation aids and the feasibility test of instruments and questions to provide a feasibility value for instruments and questions to obtain data on the level of practicality and effectiveness of the media. The feasibility test is carried out by an expert or expert by providing an assessment of the learning media, where the expert is a learning media expert in relation to augmented reality-based VOR navigation aids, the expert is a Professor of Vocational Education Engineering at

Makassar State University in the field of vocational learning media expertise who has a lot of research related to media and augmented reality and VOR navigation aids.

This stage aims to produce learning media and modules that are valid or suitable for use. The expert's statement will determine the continuation or revision of the media, modules and instruments and questions before being used in the field.

Table 4. Results of Instrument Validation for Instruction Aspects

No	Aspect/Indicator	Validator	
		First	Second
1	The instructions for the cadet response questionnaire are clearly stated	4	4
2	Assessment criteria are clearly stated	4	4
3	Assessment Criteria are clearly stated	3	4
Total Score:		**11**	**12**
Percentage (%) :		**91,67%**	**100,00%**
Criteria :		**Very Valid**	**Very Valid**

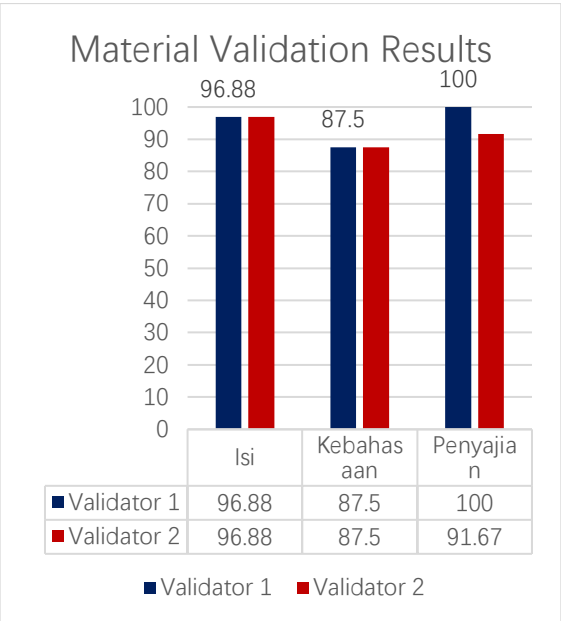

Figure 5 Graph of validation results

Based on Table 4.9, the results of the Question Validation of the Instruction Aspect show that the total score for the first validator is a value of 8 out of 8 (percentage of 100%) and has been included in the category very valid. The second validator gave a total score of 8 out of 8 (percentage 100.00%) and was categorized as very valid. The average score of the two validators was 8 out of 8 (percentage 100.00%) and it can be concluded that the instructions for the cadet assessment questions/tests were declared by both validators to be very valid.

The results of the Coverage Aspect Question Validation show that the total score for the first validator is 9 out of 12 (percentage 75%) and has been categorized as quite valid. The second validator gave a total score of 11 out of 12 (percentage 91.67%) and was categorized as very valid. The average score of the two validators was 10 out of 12 (percentage 83.33%) and it can be concluded that the coverage of the cadet assessment questions/tests was declared by both validators to be quite valid.

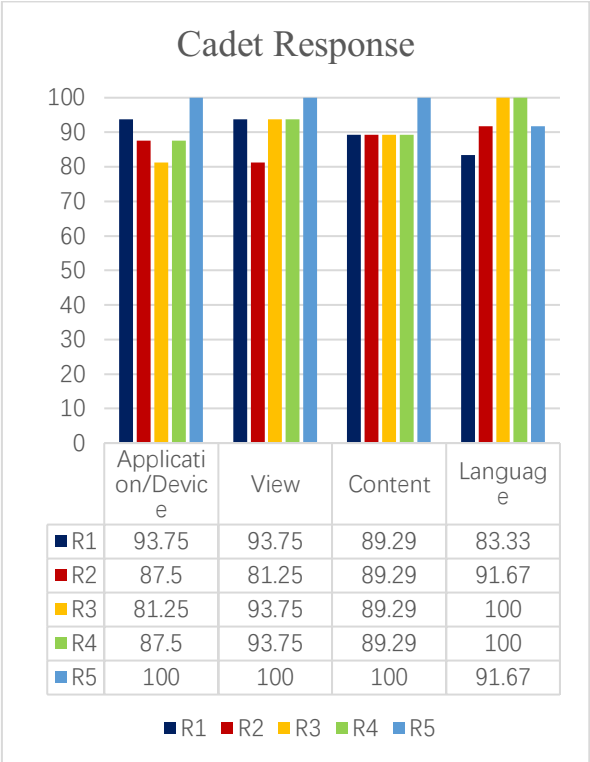

Figure 6 Graph of cadet response results

The recapitulation of the large group trial obtained an average of 91.67% application aspects, 95.83% appearance, 91.67% content and 91.67% language, so it can be concluded that augmented reality (AR) learning media for very high frequency omni directional range (VOR) courses are in the very practical category.

$$N - Gain = \frac{Value\ Postest - Value\ Pretest}{Value\ Mkasimal - Value\ Pretest}$$

$$N - Gain = \frac{87{,}1 - 43{,}8}{100{,}0 - 43{,}8} = 0{,}77$$

From these calculations, the N-Gain value is 0.77 or in the high category, so it can be concluded that the augmented reality-based VOR navigation aid media has been effective in its use.

4. CONCLUSION

This research aims to develop a learning media using Augmented Reality (AR) technology focused on the Very High-Frequency Omni Directional Range (VOR) course as a navigation aid at the Aviation Polytechnic. Using AR, this research aims to create a more interactive and real learning experience for aviation cadets in understanding the concepts and practices of navigation using VOR.

The research discussion covers the process of developing AR learning media involving needs analysis, interaction design, implementation of AR technology, and evaluation of its effectiveness in supporting learning. This research combines theoretical aspects of the VOR concept with practical applications in an AR environment so that cadets can experience the concept in a context relevant to their profession.

In addition, the discussion includes a mapping of the existing VOR course curriculum at the Aviation Polytechnic to ensure that the learning media developed is in accordance with the learning needs of cadets. Evaluation is conducted through methods that focus on measuring concept understanding, level of engagement, and effectiveness of AR learning media in improving cadets' navigation skills.

This research can make a significant contribution to the development of learning technology in the field of aviation, as well as provide a new view of the utilization of AR in a specific vocational education context. Thus, this research has the potential to improve the effectiveness of VOR course learning at Aviation Polytechnic through the utilization of innovative and relevant technology to the needs of the aviation industry.

The stages that have been carried out by researchers start from initial observations and researchers conduct validation as a feasibility test of the products developed. The validation process involves 2 (two) validators as experts in the fields of electronics, augmented reality, VOR navigation aids and artificial intelligence. From this stage, the results obtained state that the augmented reality (AR) learning media for very high frequency omni directional range (VOR) courses have been declared feasible for use in the field with the results of instrument sheet validation in the aspect of instructions of 95.84%, content aspects of 91.67%, language aspects of 90.63% so that the total percentage is 92.71% or in a very valid category. The results of media validation in the application and device aspects amounted to 93.75%, the display aspect amounted to 92.5% so that the total percentage was 93.13% or in a very valid category. The results of the material expert validation of the content aspect were 96.88%, the language aspect was 87.5% and the presentation aspect was 95.83% so that the total percentage was 93.41% or in a very valid category. In addition to media and material validation, the validation of test questions and response instruments has also been declared feasible for use in the field with the results of validation of questions/tests in the instruction aspect of 100%, the coverage aspect of 83.34%, and the language aspect of 87.5% so that the total percentage is 90.28% or in a very valid category.

Products that have been declared feasible in field trials are then implemented. The implementation stage is divided into 3 parts, namely one-to-one trials, small group trials, and large group trials. This implementation stage is carried out to determine the practicality and effectiveness of the media developed. Practicality data is obtained by giving a questionnaire to cadets containing several aspects of assessment such as, application/device aspects, display aspects, content/content aspects, and language aspects. The questionnaire shows data from each trial process, starting from the one-to-one trial, which is 88.49%; it has increased in the small group trial to 91.82% so that it can be continued in the final stage, namely the large group trial, which has increased to 92.71%, from these results it can be concluded that augmented reality (AR) learning media for very high-frequency omni-directional range (VOR) courses are in the very practical category for use by cadets.

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