DEVELOPMENT OF VIRTUAL REALITY-BASED LEARNING MEDIA ON SUPPORT INSULATOR MAINTENANCE (PDKB-TM) TO IMPROVE STUDENTS' COMPETENCE AT PLN

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Abstract

This study aims to: (1) Produce virtual reality-based learning media for PDKB-TM pedestal insulator maintenance material to improve student competency at PLN. (2) Analyze the feasibility of virtual reality-based learning media for PDKB-TM pedestal insulator maintenance material to improve student competency at PLN. (3) Measure the effectiveness of virtual reality-based learning media for PDKB-TM pedestal insulator maintenance material to improve student competency at PLN. The research method used in this study is Research and Development (R&D) using the ADDIE model, which is divided into 5 stages: Analyze, Design, Development, Implement, and Evaluate. The subjects in the study were PDKB-TM employees at PT. PLN (Persero) UP3 Palembang, 2 material experts from lecturers, 2 media experts from the Faculty of Electrical Engineering, Yogyakarta State University. The learning media was tested on 30 students, with data collected through user response questionnaires as well as pretests and posttests. Data analysis was carried out by assessing the questionnaire using a Likert scale of 1-4, then a feasibility and effectiveness test was carried out using the normalized N-Gain test to determine the level of feasibility and effectiveness of the learning media. The results of the study are in the form of (1) Virtual reality-based learning media, (2) Guidebooks containing teaching materials, operating guides for virtual reality-based learning media and maintenance work instructions for PDKB-TM supporting insulators. The results of the material expert assessment were declared worthy with the category of "very good" obtaining a percentage of 86.52%, the results of the media expert assessment were declared worthy with the category of "very good" obtaining a percentage of 80.95%, and user responses received a very good category with a percentage of 91.1%. The results of the N-gain Test with a good category of 82.82%. Suggestions for developing virtual reality learning media with more PDKB-TM competency materials at PLN.

Keywords: Learning Media, Virtual Reality

INTRODUCTION

Technological advancements in the 21st century have transformed various sectors, including vocational education and training in companies. PT PLN (Persero), as the national electricity provider, carries a strategic responsibility to develop competent human resources, particularly in the maintenance of 20 kV medium-voltage transmission networks.

The increasing demand for electricity requires optimal supply services, which can be achieved through effective and routine network maintenance. One of PLN's key strategies is conducting live-line maintenance (PDKB), which minimizes outages but poses high risks. Such tasks demand specialized teams with strong technical competence and adherence to strict safety standards.

Despite these measures, PLN reported 29 workplace accidents in 2022, resulting in 14 fatalities, mainly due to electric shocks on low- and medium-voltage networks. This highlights the need for more effective training methods to improve employee competence and reduce risks.

Research has shown that Virtual Reality (VR)-based learning media enhance participants' engagement, knowledge, and practical skills while providing immersive and interactive experiences. However, current training practices still rely heavily on conventional methods, limiting their effectiveness, especially for high-risk tasks such as support insulator maintenance in PDKB-TM.

Therefore, developing VR-based learning media is a strategic solution to improve both theoretical understanding and practical competence of PLN's PDKB employees. This innovation is expected to enhance workplace safety and strengthen the quality of electricity services provided to the public.

RESEARCH METHOD

The development of Virtual Reality-based learning media on support insulator maintenance (PDKB-TM) employed the Research and Development (R&D) method. The ADDIE model provides concepts and systematic steps that replace the traditional "classroom" paradigm with a "learning space." The term "learning space" here refers to an innovative and expansive learning environment, unrestricted by time and place, and centered on learners. This complex learning environment is further designed and guided through the stages of the ADDIE model.

This research applied the ADDIE model developed by Branch, consisting of five stages: analyze, design, develop, implement, and evaluate.

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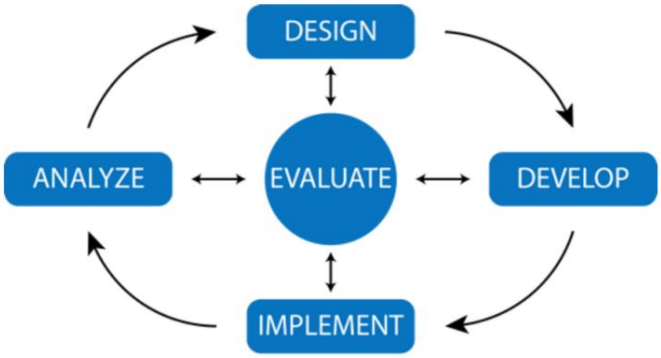

Figure 1.
ADDIE Development Model

RESULTS AND DISCUSSION

The learning media developed in this study is "Electralite" (Enhanced Learning and Critical Training for Live Maintenance), which is based on Virtual Reality.

Concept and Technology of Virtual Reality in Technical Education

Virtual Reality (VR) has been proven to create simulated environments that closely resemble the real world, allowing users to experience situations that are otherwise impossible to achieve through conventional learning methods. In the context of PDKB-TM training, Electralite provides an ideal solution to address the high risks of accidents and safety concerns inherent in direct practice on live electrical networks. Electralite utilizes the Meta Quest 2 (Oculus Quest 2) headset as its main platform, enabling use without requiring a PC.

PDKB is a maintenance method that allows various activities on electrical network equipment to be carried out while the system remains energized, without shutting down power. This method offers significant advantages from both technical and economic perspectives, reducing losses due to outages and improving service continuity for consumers.

Application of the ADDIE Development Model

The ADDIE development model was applied in the development of Electralite, with stages including Analyze, Design, Develop, Implement, and Evaluate.

Product Testing

Product trials were conducted to assess the feasibility and effectiveness of the Virtual Reality-based learning media on the subject of support insulator maintenance. A questionnaire using a 1–4 Likert scale was distributed, followed by validity testing, reliability testing, and feasibility assessment to determine the accuracy and consistency of the instrument.

Expert Validation of Media

The validation of learning media aimed to determine the feasibility of the Virtual Reality-based learning tool for support insulator maintenance. Validation was carried out by

two media experts using a questionnaire that covered aspects of technical quality and visual quality. The analysis results from both experts are presented as follows:

a. Technical Quality Aspect

Based on the analysis, the technical quality aspect consisted of 15 items with a maximum score of 60 and a minimum score of 15. The first media expert gave a score of 49, while the second expert gave a score of 50. From these results, the ideal mean (Mi) and standard deviation (Sbi) were obtained with the following details:

Table 1.
Questionnaire Assessment Data (Technical Quality Aspect)

1	Number of Items	15
2	Minimum Score	15
3	Maximum Score	60
4	Average	49,5
5	Mi (Ideal Mean)	37,5
6	Sbi (Standard Deviation)	7,5

Based on the test results presented in the table above, the data can then be converted as shown in the following table:

Table 2.
Questionnaire Assessment Data (Technical Quality Aspect)

Score Range	Category
$48.75 < X \leq 60$	**Very Good**
$37.5 < X \leq 48.75$	Good
$26.25 < X \leq 37.5$	Fairly Good
$15 < X \leq 26.25$	Very Good

The analysis of the technical quality aspect showed that the average score obtained from both media experts was 49.5. Based on the conversion table derived from the values of Mi (Ideal Mean) and Sbi (Standard Deviation), the average score falls within the range of $48.75 < X \leq 60$, which categorizes the assessment result as “Very Good.”

b. Visual Quality Aspect

Based on the analysis, the visual quality aspect consisted of 6 items, with a maximum score of 24 and a minimum score of 6. The first media expert gave a score of 18, while the second expert gave a score of 19. From these results, the values of Mi (Ideal Mean) and Sbi (Standard Deviation) were obtained with the following details:

Table 3.
Questionnaire Assessment Data (Visual Quality Aspect)

1	Number of Items	6
2	Minimum Score	6
3	Maximum Score	24
4	Average	18,5
5	Mi (Ideal Mean)	15
6	Sbi (Standard Deviation)	3

Based on the test results presented in the table above, the data can then be converted as shown in the following table:

Table 4.
Questionnaire Assessment Data (Visual Quality Aspect)

Score Range	Category
$19,5 < X \leq 24$	Very Good
$15 < X \leq 19,5$	**Good**
$10,5 < X \leq 15$	Fairly Good
$6 < X \leq 10,5$	Very Poor

The analysis of the technical quality aspect showed that the average score obtained from the two media experts was 18.5. Based on the conversion table derived from the values of Mi (Ideal Mean) and Sbi (Standard Deviation), the average score falls within the range of $15 < X \leq 19.5$, thus the assessment result is categorized as “Good.”

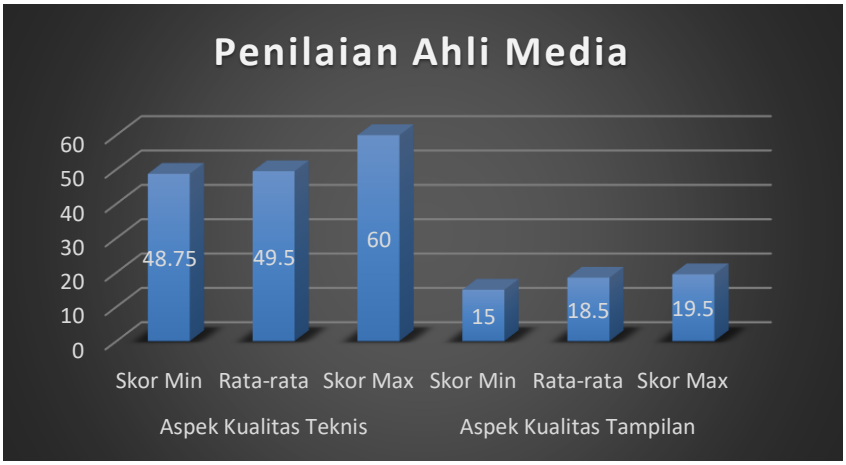

Figure 2.
Graph of Media Expert Assessment Results

Based on the average score calculation for each aspect, the bar chart above shows that the technical quality aspect achieved an average score of 49.5 out of a maximum score of 60, which is higher compared to the visual quality aspect, which obtained an average score of 18.5 out of a maximum average of 19.5. This indicates that the technical quality aspect has the highest level of feasibility.

Expert Material Assessment

The purpose of material validation is to determine the level of feasibility of the content related to the Virtual Reality learning media developed in this study. Validation was carried out by two subject matter experts.

a. Learning Achievement Aspect

Based on the analysis, the learning achievement aspect consisted of 14 items, with a maximum score of 56 and a minimum score of 14. The first subject matter expert gave a score of 49, while the second expert gave a score of 47. From these results, the values of Mi (Ideal Mean) and Sbi (Standard Deviation) were obtained with the following details:

Table 5.
Questionnaire Assessment Data (Learning Achievement Aspect)

1	Number of Items	14
2	Minimum Score	14
3	Maximum Score	56
4	Average	48
5	Mi (Ideal Mean)	35

6	Sbi (Standard Deviation)	7

Based on the test results presented in the table above, the data can then be converted as shown in the following table:

Table 6.
Feasibility Criteria (Learning Achievement Aspect)

Score Range	Category
45,5 < X ≤ 56	**Very Good**
35 < X ≤ 45,5	Good
24,5 < X ≤ 35	Fairly Good
14 < X ≤ 24,5	Very Poor

The analysis of the learning achievement aspect showed that the average score obtained from the two material experts was 48. Based on the conversion table derived from the values of Mi (Ideal Mean) and Sbi (Standard Deviation), the average score falls within the range of 45.5 < X ≤ 56, thus the assessment result is categorized as "Very Good."

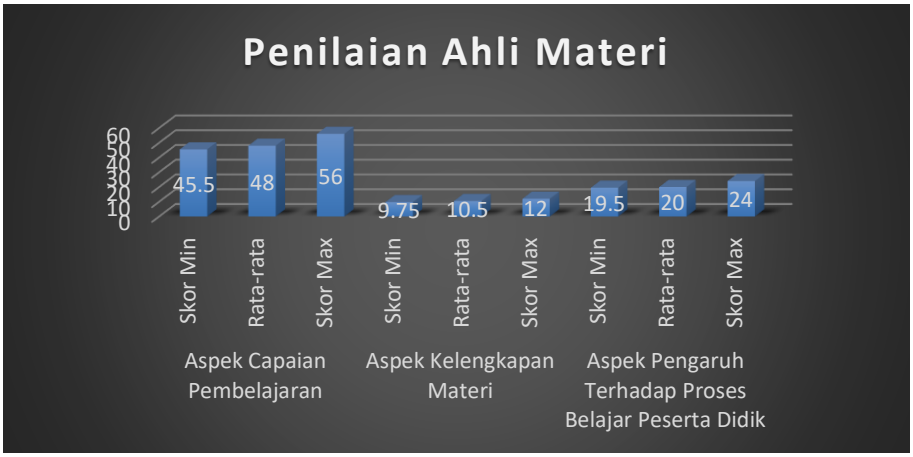

Figure 3.
Subject Matter Expert Assessment Chart

Based on the average score calculation for each aspect, the bar chart above shows that the learning achievement aspect obtained an average score of 48 out of a maximum score of 56, which is the highest compared to the content completeness aspect, which obtained an average score of 10.5 out of a maximum score of 12, and the learning process impact aspect, which obtained an average score of 20 out of a maximum score of 24. This indicates that the learning achievement aspect has the highest level of feasibility.

b. Visual Quality Aspect

Based on the analysis, the visual quality aspect consisted of 6 statements, with a maximum score of 24 and a minimum score of 6. The values of Mi (Ideal Mean) and Sbi (Standard Deviation) can be described in the following table:

Table 7.
Questionnaire Assessment Data (Visual Quality Aspect)

1	Number of Items	6
2	Minimum Score	6
3	Maksimum Score	24
4	Average	23,3
5	Mi (Ideal Mean)	15
6	Sbi (Standard Deviation)	3

Based on the above assessment results, the following conversion was obtained as presented below:

Table 8.
Feasibility Criteria (Visual Quality Aspect)

Score Range	Category
19,5 < X ≤ 24	**Very Good**
15 < X ≤ 19,5	Good
10,5 < X ≤ 15	Fairly Good
6 < X ≤ 10,5	Very Poor

The analysis of the learning achievement aspect showed an average score of 23.3. Based on the conversion table using the values of the Ideal Mean (Mi) and Standard Deviation (Sbi), this average score falls within the range of $19.5 < X \leq 24$, thus the assessment is classified in the "Very Good" category.

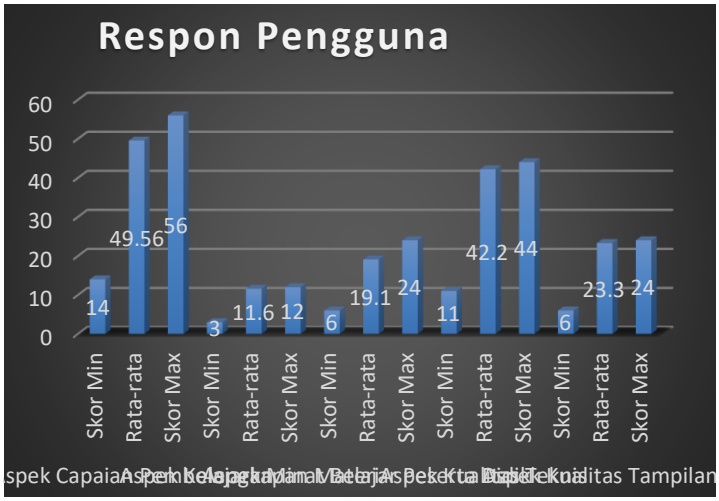

Figure 4.
User Feasibility Chart

Based on the calculation of the average score for each aspect, it can be seen in the bar chart above that the learning achievement aspect obtained an average score of 49.56 out of a maximum average score of 56, making it the highest compared to the aspects of content completeness, student learning interest, technical quality, and display quality. This indicates that the learning achievement aspect achieved the highest level of feasibility.

Validity Test

The validity test, based on expert judgment, was calculated using Aiken's formula to determine the content validity of the instrument. The following table presents the calculation results and categories based on Aiken's formula:

Table 21.
Expert Validity Test Results

No.	Validity Test	Aiken's V Coefficient	Category
1	Media	0,754	Very High
2	Materi	0,819	Very High

Based on the calculation of Aiken's V coefficients shown in the table above, the assessment data from each expert for each statement item were obtained. Referring to Aiken's V validity criteria, which range from 0 to 1, it can be concluded that the media content validity reached 0.754, while the material validity was 0.819.

Reliability Test

A reliability test was conducted to examine the consistency of this assessment composition based on accumulated repeated stability (Mw et al., 1997). The test was performed using Cronbach's Alpha in SPSS v.26. The results of the user reliability test can be seen in the following figure:

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.975	40

Figure 5.
Reliability Test Results

The reliability test is considered reliable if the calculated Cronbach's Alpha value is ≥ 0.7. In this study, the calculated Cronbach's Alpha value was 0.975, indicating that each item in the user response instrument is reliable.

The reliability test for media experts was conducted using inter-rater reliability with the calculation of the Cohen's Kappa coefficient. The resulting data can be seen in the following table:

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	-.137	.205	-.659	.510
N of Valid Cases		23			

Figure 6.
Media Expert Reliability

Based on the table above, the test results show that the Approx. Sig score is 0.510, which is greater than 0.05. If the Approx. Sig value is less than 0.05, it indicates that there is a difference of opinion between the two media experts. Therefore, the test results above indicate that there is no significant difference between the two media experts.

The reliability test for material experts was conducted using inter-rater reliability with the calculation of Cohen's Kappa coefficient. The resulting data can be seen in the following table:

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	-.037	.204	-.176	.861
N of Valid Cases		21			

Figure 7.
Reliability of Material Experts

Based on the table above, the test results indicate that the Approx. Sig score is 0.861, which is greater than 0.05. An Approx. Sig value less than 0.05 would indicate a difference of opinion between the two material experts. Therefore, the test results above can be concluded that there is no significant difference between the two material experts.

CONCLUSION

Based on the results of the research and development of Virtual Reality-based learning media on support insulator maintenance (PDKB-TM), the following conclusions can be drawn:

1. The product developed is a Virtual Reality learning media on support insulator maintenance (PDKB-TM) at PLN, designed through the stages of Research and Development (R&D) using the ADDIE model (Analyze, Design, Development, Implementation, Evaluation).
2. The subject matter expert's assessment indicated that, in terms of learning achievement, content completeness, and its influence on the learning process, the product was categorized as "Very Good." The media expert's assessment showed that the technical quality aspect was categorized as "Very Good," while the visual quality aspect was rated "Good." Feedback from 30 students at PLN School indicated a "Very Good" rating for learning achievement, content completeness, technical quality, and visual quality, while students' learning interest was rated "Good."
3. Validity testing using Aiken's V showed a "Very High" category with a score of 0.754 for media validity and 0.819 for content validity. The effectiveness test of the learning media, based on pre-test and post-test results, showed an effectiveness rate of 82.82%, which indicates that the Electralite Virtual Reality-based learning media has a high level of effectiveness.

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