

Implementation of Augmented Reality-Based Mobile Learning Media in Vocational High Schools

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Abstract. This study aims to develop a mobile learning medium based on Augmented Reality that is feasible and effective for improving students' learning outcomes in Vocational High Schools. The research method used is Research & Development, employing the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The study used questionnaire instruments for validation by subject matter experts, media experts, design experts, as well as media trial results. The quantitative data analysis techniques used in this research include data from the feasibility and effectiveness questionnaires, along with qualitative data in the form of observations and documentation. The feasibility validation assessment was carried out in five stages: validation by subject matter experts obtained an average score of 95.1%, validation by instructional media experts obtained an average score of 88.7%, validation by instructional design experts obtained a score of 97.6%, small group trials obtained a score of 86.2%, medium group trials obtained a score of 92.5%, and field trials obtained a score of 98.6%. The average score from the expert validations and trials was 93.1%, indicating that the mobile learning medium based on Augmented Reality is feasible for use. The results of normality and homogeneity tests showed that the research data were normal and homogeneous. The effectiveness test using a one-tailed T-test yielded a score of 0.000 and, based on the predetermined criteria (if $\text{Sig.} \leq 0.05$, then H_0 is rejected), there was a significant difference between the post-test results of the control class and the post-test results of the experimental class. Therefore, it can be concluded that the mobile learning medium based on Augmented Reality is effective for use.

Keywords: Learning Media, Augmented Reality, Learning Outcomes

1 Introduction

Technological developments in Indonesia have made rapid progress in the fields of communication, education, economy, agriculture, industry, and many other aspects of human life, all of which have undergone changes as a result of technological advancement. However, technology can also have negative impacts on human life. One of the negative impacts caused by technological development is the reduction in em-

ployment opportunities. This is due to human jobs increasingly being replaced by machines or robots, leading industries to no longer need humans as their workforce. According to data from BPS (Statistics Indonesia), in 2020 the unemployment rate for graduates ranging from elementary school to university reached 48.91%. In 2021 it was 42.13%, and in 2022 it decreased to 36.92%. Based on the total unemployment percentage in Indonesia, vocational high school (SMK) graduates have the highest percentage, with 13.55% in 2020, 11.13% in 2021, and 9.42% in 2022. Vocational high school graduates, who are expected to be ready to enter the workforce or create job opportunities, instead contribute the highest unemployment rate. The implementation of the *Kurikulum Merdeka* (Independent Curriculum) currently being carried out is one of the government's efforts to reduce the unemployment rate in Indonesia by aligning the curriculum taught in schools with the rapidly evolving needs of industry. Aligning the curriculum is an effective step to adjust the curriculum implemented in schools to meet the demands of the industrial world. In addition to this, one solution that can be developed is to prepare the learning process to match real activities that students will experience during their fieldwork practice.

One way to make the learning process feel as real as the conditions students experience during fieldwork practice in the industrial world is by using Augmented Reality (AR)-based learning media. *Augmented Reality* (AR) is a technology in which virtual objects are displayed interactively in real form (real time), and there is integration between objects in three dimensions, namely virtual objects that are integrated in the real world [1]. The purpose of augmented reality is to advance technology by combining computer-generated digital content with the real world in real time. Augmented reality technology has been developed for Android smartphones. Smartphones with Android operating systems have many open-source platforms that make it easier to develop applications [2]. AR-based learning media is one of the tools that can increase students' interest in learning by providing a unique and immersive experience with the learning material.

This is in line with the development of augmented reality-based learning media in the current digital era which has been widely carried out, such as in previous research conducted [3] titled "*Designing Augmented Reality in the Automotive Field for Vocational High School Students in the Motorcycle Engineering Department*" with the research title Designing augmented reality in the automotive sector for SMK students majoring in Motorcycle Engineering in 2022. The results were found using a Likert scale measurement on respondents totaling 30 students who produced a value of 99% with the criteria of strongly agreeing that the motorcycle device recognition application using augmented reality technology can be used as a learning support. In a study conducted by [4] data from pre-test and post-test results were collected based on students' answers to questions prepared by the researchers. The results showed an average pre-test score of 51.72% and a post-test score of 72.66%. The pre-test scores were obtained without the use of augmented reality, while the post-test scores were achieved after using augmented reality in the learning process. Based on this, it was concluded that there was an increase in students' scores after implementing augmented reality in the learning process, with an improvement of 20.94%. These results were supported by a survey evaluating the effectiveness and usefulness of the mobile aug-

mented reality application, which was given to all students and obtained a confidence interval score of 95%. However, the use of augmented reality-based learning media has not yet been fully developed. Further development is still needed, especially in utilizing augmented reality to create learning experiences that feel as real as on-the-job training sessions. It can also help address the issue of smartphone misuse, which often leads to decreased enthusiasm and motivation for learning, resulting in poor student achievement.

These problems can be overcome by trying to develop mobile learning media based on augmented reality, with this media it is hoped that it can overcome the problems that arise and can have a positive impact on students and become a new method for teachers in overcoming similar problems and can be a renewable solution in creating a more real learning process in order to increase students' enthusiasm and motivation to learn so that it will have an impact on improving student learning outcomes. High enthusiasm and motivation to learn will certainly produce good learning outcomes. With good learning outcomes, it will certainly produce competent graduates who meet industrial standards, which can make it easier for these graduates to be accepted for work and can even create new jobs. The purpose of this study is to analyze the feasibility of mobile learning media based on augmented reality for vocational high schools (SMK) and to analyze the effectiveness of mobile learning media based on augmented reality for vocational high schools (SMK).

2 Method

The location of this research is at one of the vocational high schools in the city of Medan, namely SMK Negeri 5 Medan, which is located at Jl. Timor No. 36, Gaharu, Medan Timur District, Medan City, North Sumatra, 20235. The research will be conducted during the even semester of the 2024/2025 academic year.

The population of this study consists of 11th-grade students majoring in Light Vehicle Engineering (TKRO) at SMK Negeri 5 Medan. The sample used in this research includes students from class XI TKRO 1 and XI TKRO 2 at SMK Negeri 5 Medan. Class XI TKRO 1 will serve as the control group, consisting of 36 students, while class XI TKRO 2 will serve as the experimental group, also consisting of 36 students. The sampling in this study used a purposive sampling technique, which is a sampling method based on the researcher's judgment, where the researcher considers that the desired research elements are present in the selected sample members, and also based on recommendations from the light vehicle engineering subject teacher in that class.

The research method used in this study is the research and development (R&D) method, with the development model employed being the ADDIE development model. According to Mulyatiningsih in Rohaeni (2020), the ADDIE model is considered more rational and comprehensive compared to other models, making it suitable for various types of product development, such as models, learning strategies, learning methods, media, and teaching materials. The ADDIE development model consists of five stages, namely: 1) analysis, 2) design, 3) development, 4) implementation, and 5) evaluation. According to [5] the ADDIE model is considered more rational and com-

prehensive compared to other models, making it suitable for various types of product development, such as models, learning strategies, teaching methods, media, and instructional materials.

The first stage is to analyze needs, which includes curriculum analysis, material analysis, and identifying existing problems within the learning environment, technological developments, and students' characteristics. The second stage is the design stage, which involves creating a storyboard aimed at planning the concept for product development. The third stage is the development stage, which involves developing solutions based on the problems previously analyzed in order to improve the product's quality so that an effective learning media can be created and prepared for implementation. The fourth stage is implementation, where the developed product is applied to the target audience or research subjects and then implemented in actual conditions. The fifth stage is evaluation, which aims to assess the feasibility of the developed product to determine whether it is suitable for use in the learning process.

2.1 Data Analysis Technique

Data collection in this research was carried out using questionnaires. The questionnaires were used to assess the validity of the augmented reality-based learning media that was developed. The validation process was conducted in three stages: validation by subject matter experts, validation by learning media experts, and validation by instructional design experts. The data analysis in this study includes feasibility testing and effectiveness testing. The feasibility test is conducted to determine the suitability of the augmented reality-based learning media. The analysis results are obtained based on the validity scores from the questionnaires that were assessed by the subject matter experts, media experts, and instructional design experts. A Likert scale is used to evaluate the quality of the developed media based on several criteria, which are presented in Table 1 below.

Table 1. Item Validation Assessment Criteria

Score	Category
4	Very Good
3	Good
2	Not Good
1	Not Good

The assessment of the developed media is calculated based on the percentage of indicators in each aspect assessed using the following formula:

$$Score\ Presentation = \frac{Number\ of\ scores\ per\ category}{Total\ Number\ of\ scores\ per\ category} \times 100\% [6]$$

The calculation results using this formula produce figures in percentage (%) form. These results are then classified into percentage categories, which are interpreted into qualitative descriptive statements as shown in Table 2 below.

Table 2. Percentage Classification

Criteria	Interval
Very Eligible	81% - 100%
Eligible	61% - 80%
Quite Eligible	41% - 60%
Less Eligible	21% - 40%
Not Eligible	0% - 20%

Source: [7]

The percentage classification table is used as a reference to determine the feasibility of the developed media based on the percentage score obtained for each aspect evaluated by the subject matter expert, media expert, and instructional design expert. The effectiveness test is conducted to determine the effectiveness of the augmented reality-based learning media.

The effective test results are obtained through a T-test. Before conducting the T-test, several statistical tests are carried out, such as the normality test and the homogeneity test. The T-test is conducted using the following formula:

$$t = \frac{x_1 - x_2}{s \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where S is the combined variance square root calculated by the formula:

$$S^2 = \frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2} \text{ where } S = \sqrt{S^2}$$

Description:

t = calculated value obtained.

x_1 = average score of the experimental class.

x_2 = average score of the control class.

n_1 = number of experimental class subjects

n_2 = number of control class subjects

S_1^2 = variance of the experimental class group

S_2^2 = variance of the control class group.

S = combined variance.

Testing criteria: H_a is accepted If $t_{count} < t_{table}$ and H_o is rejected If $t_{count} > t_{table}$ obtained based on the t distribution list with $dk = (n - 1)$ and a significance level of $\alpha = 5\%$. Then it can be said that the media is "Effective" used.

3 Results and Discussion

The initial stage in implementing this research is to conduct a needs analysis of students and teachers of SMK Negeri 5 Medan. This stage is carried out by distributing a needs questionnaire on the concept of augmented reality-based learning media that will be developed. The observation stage is carried out by analyzing the curriculum such as the curriculum devices used at SMK Negeri 5 Medan with the aim of formulating learning outcomes and learning objectives that will be used. Interviews were conducted with subject teachers regarding any obstacles encountered during the learning process and questionnaires were distributed to analyze the needs of students and teachers. The results of the questionnaires distributed obtained data stating that students and teachers need the development of learning media, namely by utilizing augmented reality as a supporting medium in the learning process of light vehicle engineering.

Based on the results of the needs analysis, it was concluded that the development of augmented reality-based mobile learning media was needed by students and teachers to support the achievement of light vehicle engineering learning on the 1000 km periodic maintenance material. Data from the results of the needs analysis of students and teachers at SMK Negeri 5 Medan can be seen in the table.

Table 3. Data from the analysis of the needs of students and teachers at State Vocational School 5 Medan

No.	Question	Answer	Number of Students	Percentage
1	Does the teacher teach the material on 1000 km periodic vehicle maintenance well, so that the learning process becomes enjoyable?	Yes	24	66,7%
		No	12	33,3%
2	Do you have difficulty understanding the material using printed books?	Yes	26	72,2%
		No	10	27,8%
3	Do you often use your smartphone and access the internet to view the material being discussed?	Yes	36	100%
		No	0	0%
4	Do you agree if the learning process uses smartphones?	Yes	36	100%
		No	0	0%

Based on the results of the integrity analysis questionnaire distributed to students and teachers, the following conclusions were obtained:

1. All students and teachers stated that they had never used augmented reality-based learning media.
2. All students and teachers stated that they agreed if augmented reality-based learning media were used in learning.

3. All students and teachers stated that they agreed if the use of augmented reality-based learning media could improve student learning outcomes.

The next stage is designing and developing the Augmented Reality-based learning media based on the needs analysis of students and teachers. The development stage involves creating the Augmented Reality-based learning media, which is then tested to assess the validity of the developed learning media. The validation stage is carried out to determine whether the developed learning media is feasible to implement or not. The validity results are obtained from the questionnaire responses given by subject matter experts, instructional media experts, and instructional design experts. These validity results can be seen in the following table.

Table 4. Average Percentage of Expert Validation Results

No	Category	Percentage Average Score	Criteria
1	Validation by Material Experts	95,1 %	Very Worthy
2	Validation by Learning Media Experts	88,7 %	Very Worthy
3	Validation by Learning Design Experts	97,6 %	Very Worthy
Average		93,8 %	Very Worthy

Based on the data in the table above, the average validation score for the material experts was 95.1%, the average validation score for the learning media experts was 88.7%, the average validation score for the learning design experts was 97.6%, and the average validation score by all experts was 93.8%, thus achieving a very suitable criteria. Based on the average validation scores from the experts, it can be concluded that the developed augmented reality-based mobile learning media is suitable for use. The trial phase was conducted to determine the suitability of the developed learning media based on the results of the pilot test with students. This trial was conducted in several stages, including small group trials, medium group trials, and field trials. The results of these trials are shown in the following table.

Table 5. Average Percentage of Trial Results

No	Category	Percentage Average Score	Criteria
1	Small Group Trial	86,2 %	Very Worthy
2	Medium Group Trial	92,5 %	Very Worthy
3	Field Trial	98,6 %	Very Worthy
Average		92,4 %	Very Worthy

Based on the data in the table above, it can be seen that the average score obtained from the trials was 92.4%, which indicates that the trials conducted met the criteria of being highly feasible. Recapitulation of Final Student Achievement Results for the Control and Experimental Classes Based on the research conducted at SMK Negeri 5 Medan with students of class XI TKRO 1 and XI TKRO 2, a recapitulation of the average final student achievement results was obtained, comparing the control class

(which used conventional learning media) with the experimental class (which used mobile learning media based on Augmented Reality). A description of the average final achievement scores of the control class and experimental class can be seen in the following table.

Table 6. Average Final Ability Scores of Control Class and Experimental Class Students

Class	n	Average value
Control	36	72,06
Experiment	36	80,94

Based on the data in the table above, it can be seen that the final achievement scores of the two classes show different average values. The average score of the control class was 72.06, while the experimental class scored an average of 80.94. This indicates that the final achievement of the experimental class students was higher than that of the control class students.

3.1 Feasibility Test

The feasibility test was conducted through product validation by subject matter experts, instructional media experts, and instructional design experts. The comments and suggestions from these experts are crucial in determining whether the developed product is feasible or not. After the validation tests conducted by the experts and trials with students, revisions were made based on the feedback from the experts and the results of the student trials. The average percentage of the validation results can be seen in the following table.

Table 7. Average Percentage of Validation and Trial Results of Augmented Reality-Based Mobile Learning Media

No	Category	Percentage Average Score	Criteria
1	Validation by Material Experts	95,1 %	Very Worthy
2	Validation by Learning Media Experts	88,7 %	Very Worthy
3	Validation by Learning Design Experts	97,6 %	Very Worthy
4	Small Group Trial	86,2 %	Very Worthy
5	Medium Group Trial	92,5 %	Very Worthy
6	Field Trial	98,6 %	Very Worthy
Average		93,1 %	Very Worthy

Based on the data presented in the table above, the average validation and trial results reached 93.1%. Therefore, it can be concluded that the augmented reality-based mobile learning media is "suitable" for use.

3.2 Effectiveness Test

The effectiveness test was conducted to evaluate whether the use of augmented reality-based mobile learning media can improve student learning outcomes. The hypothesis was tested using a one-tailed T-test with the following criteria: If the Sig. ≤ 0.05 , then H_0 is rejected (there is a significant difference between the post-test of the control class and the post-test of the experimental class). This means that the learning media used in the experimental class is superior to the control class. In this case, it can be concluded that the developed augmented reality-based mobile learning media is proven to be superior to conventional learning media.

4 Conclusion

Based on the results of the research on the development of Augmented Reality (AR)-based mobile learning media at SMK Negeri 5 Medan, the following conclusions were obtained:

The research product is an Augmented Reality-based mobile learning media. The feasibility assessment was conducted in five stages: validation by material experts, with an average score of 95.1%; validation by learning media experts, with an average score of 88.7%; validation by learning design experts, with an average score of 97.6%. Small group trials, with an average score of 86.2%; medium group trials, with an average score of 92.5%; and field trials, with an average score of 98.6%. Overall, the assessment results from this stage yielded a total score of 93.1%, categorized as "Very Feasible." The results of the research conducted at SMK Negeri 5 Medan on grade XI TKRO 1 students yielded a final ability score of 72.06. In class XI TKRO 2 students, the final ability results were obtained with an average student score of 80.94. There is a significant difference in results between the learning outcomes of students taught using conventional learning media and the learning outcomes of students taught using Augmented Reality-based mobile learning media, thus it can be concluded that the Augmented Reality-based mobile learning media developed meets the "Effective" criteria for use. Based on this data, it can be concluded that the objectives of this study, which are to analyze the feasibility and effectiveness of augmented reality-based mobile learning media, have been achieved, as evidenced by the results of the study which show that the developed media is feasible and effective to use.

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