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Development of 3D Hologram Learning Media based on Holo-SDK for Multimeter Introduction

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ABSTRACT

Through the growth of learning media, the application and development of 3D hologram technology have penetrated several industries, including education. Learning media from several studies have not been able to involve students effectively. This study aims to determine the development, feasibility, practicality, and effectiveness of the Holo-SDK for multimeter introduction learning media in Basic Electronics Engineering. The R&D method used the ADDIE development model (analysis, design, development, implementation, and evaluation) with a descriptive quantitative approach. The research instrument consisted of a questionnaire in the form of a validation and practicality instrument and a test in the form of an effectiveness instrument. The results show that 3D hologram media based on Holo-SDK is feasible, practical, and effective in improving student learning outcomes as indicated by the difference in test scores before and after using the media through the sample t-test and N-Gain test.

Keywords: Learning media, 3D Hologram, Holo-SDK, ADDIE method

INTRODUCTION

Following the Republic of Indonesian Law No. 20 of 2003 content of article 40, educators are obliged to optimize student learning achievement by creating creative, communicative, and fun learning that effectively encourages students to learn more actively and better to create quality prospective graduates. Article 1 explains that education is a consciously planned effort to achieve goal-oriented learning conditions so that students can actively build and enhance their own potential; the role of the learning atmosphere also greatly determines the growth of the potential that students have during the learning process (RI Law No. 20 about the National Education System, 2003). For the learning process to be interesting and to improve student learning outcomes, the teacher's efforts in realizing this goal include providing material through innovative learning media. Media comes from the latin word *Medius*, which means introduction or intermediary, and the utilization of the media as an intermediary to send information from sources to recipients of information (Pribadi, 2017). Besides functioning as a teaching aid for students, learning media can be a learning resource (Pratama & Khumaedi, 2021; Nurfa et al., 2022). An effective and efficient learning process is the goal of using media that contain information and knowledge (Pribadi, 2017; Samudro et al., 2022).

Interesting sources of teaching materials or learning media are still lacking, and teachers are trying to carry out active learning in an interesting learning process (Adhyaksa

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& Santosa, 2018). Observations made by researchers of students and teachers in the Basics of Electronic Engineering subject at SMKN 1 Tonjong show that the multimeter introduction and measurement material have a level of activity. Student learning achievement is still relatively low due to a lack of student interest during learning, a lack of student motivation to learn, low student concentration while participating in learning, innovative learning media used by teachers that have not attracted students' interest, and the teacher’s use of the lecture learning method. The lecture learning method causes the teacher to have to explain repeatedly to students individually, making it less effective for students and teachers. Even though the introduction and measurement of a multimeter are basic materials that must be mastered by students (Saputro et al., 2022). Media use of PowerPoint slides with the lecture method by the teacher could not lead to interactivity in learning (Sudjana & Rivai, 2010).

Learning media that are less interactive can cause student learning outcomes to decrease (Agusti & Aslam, 2022), other learning media based on interactive CDs can be operated and are feasible based on the results of trials on students (Suprapta et al., 2018), this learning media has not added animation to simulate the use of a multimeter and has not tested the effectiveness of using the media. Research that develops video-based multimeter learning media with media results obtains positive responses. However, the videos in the form of tutorials produced have low quality and lack interactivity (Yulanto et al., 2022). Therefore, interactive learning media is an innovation in carrying out the learning process to improve student learning achievement, which can make learning more interesting and clear; there is interactivity and energy and time efficiency (Wahid, 2018).

The development of computer technology has many benefits in the field of education. The rapid development of technology has introduced new technologies that allow humans to interact with 3D objects through augmented reality technology (Bach et al., 2018). Augmented Reality (AR) is a combination of elements of the virtual world with the real world as a system with three characteristics, namely, combining real and virtual visualization technology that combines real-time computer-generated images recorded in real-life 3D to create an enhanced representation of reality (Koutromanos et al., 2015).

One of the media innovations that are developing using AR technology in learning is the 3D hologram. A hologram is a product of holographic technology that utilizes optical engineering technology by utilizing the use of a laser that is emitted in a certain area which, in the end, looks like a living object that blends in with the surrounding environment (Tawaqqal et al., 2017). According to Peyghambarian, 3D holograms are 3D images from computer processing light reconstruction or light recordings from objects projected onto holographic media (Suharto & Priyanto, 2022). 3D hologram technology can create 3D-like illusions for viewers of audio and visual content to explain difficult concepts or texts by transforming complex information into simpler forms (Ahmad, 2014).

Concerning hologram technology as a learning medium, it is explained that the introduction of 3D hologram technology will greatly improve the teaching of students about technical and mechanical science (Sipka, 2016). 3D hologram technology can improve the quality of student learning, with 3D hologram animation able to attract students' interest and 3D hologram is a very creative innovation that can develop understanding and increase children's interest in learning (Hoon & Shaharuddin, 2019).

Research on three visualization environments to determine the exploratory effectiveness of 3D visualization shows that each tested environment is more effective for a particular task. However, the desktop environment is still the fastest and most appropriate in almost all cases (Bach et al., 2018). The use of desktop-based AR as a medium for visualizing virtual models helps students make it easier to understand the material being studied and provides new experiences in learning (Afandi et al., 2019). Computer-generated 3D virtual worlds will work best when virtual worlds are seamlessly integrated with real 3D spaces

(Kim et al., 2014). This desktop requires software to visualize effective 3D holograms using a Software Development Kit (SDK). To create AR, teachers and students can use the tools Metaverse, Holo-SDK, Waypoint EDU, and others. Holo-SDK is a software development kit that uses the effect of anaglyph for 3D visualization. Utilizing Holo-SDK helps facilitate developers in the development of a game as well as learning media with the features offered, namely the 3D effect feature with 3D anaglyphs by offering five types of shader anaglyphs, namely shader half-color anaglyphs, optimized anaglyphs 3, true anaglyphs, color anaglyphs, and dubois anaglyphs. In addition, Holo-SDK also has a webcam technology feature that is used to track the position of the user's head and produce an image display from the user's perspective that can be easily implemented. 3D displays are in the form of red and blue images in 3D stereogram mode or format side-by-side to provide passive and active 3D viewing effects (Holo SDK, 2020).

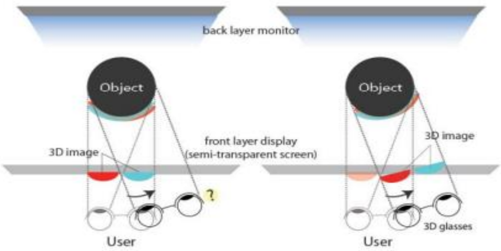

Figure 1. Head Tracking Interaction System
Source: Kim et al. (2014)

This research has a goal to develop Holo-SDK-based media learning that is valid, practical, and effective to support the learning process at SMK Negeri 1 Tonjong in the multimeter introduction material for grade 10. This is expected to create media that is appropriate, according to experts, practical for students and teachers, and effective in supporting students in improving their learning achievement.

METHODS

The research used this type of development research. The stage used was the ADDIE (Analyze, Design, Development, Implement, and Evaluation) model. In this study, the result is a product in the form of an educational application, namely 3D hologram media of a multimeter-based measuring instrument introduction based on Holo-SDK to support the learning of grade 10 students. The test subjects were 36 students from class X and 1 electronic engineering teacher at SMKN 1 Tonjong, Brebes Regency. The ADDIE development stage is shown in Figure 2.

The analysis stage is the stage of gathering information in the form of materials needed for development planning into products in the form of learning media. This stage included analyzing needs, media and learning materials, and the software needed to make products.

The design stage was the product planning stage that would be developed to facilitate researchers in designing instructional media. At this stage, it contained the planning of data collection criteria, including the preparation of test references (pretest and post-test) according to the material at the analysis stage, the collection of materials that can support the creation of media, such as audio, images, videos, and so on, and red blue, or red-cyan glasses for the 3D visualization tool, a flowchart, and a sketch (storyboard).

The development stage was the process of making learning media following the results of the previous design. The creation of a 3D model of a multimeter was done with 3D software mixes. The application development for 3D hologram media used the Software Unity. At the development stage, the media was adjusted to the design that had been planned according to the flowchart, storyboard, and navigation structure that had been designed using Software Unity. The application process included making slides, using database, testing, and publishing.

The implementation stage was carried out after the media prototype was completed. The next process was: (1) The media and material feasibility test, assessed by experts as expert validation to be able to know the appropriate quality of learning media and repair material before learning media was used by students; (2) Learning media improvement, this stage was carried out after learning media was assessed by carrying out improvements according to responses, criticisms, input, and suggestions from expert validation, (3) Validity test and reliability test of test instruments, and (4) Field trials, namely media distributed to teachers and students as learning media. Testing of this prototype was carried out to determine the generic quality.

The evaluation stage was the final stage for conducting statistical analysis to determine the practicality and effectiveness of learning media. Researchers used statistical analysis to measure the practicality of media users base on the results of teacher and student responses. Researchers used statistical analysis to measure the media's effectiveness in the test results of the pre-test and post-test to compare student learning outcomes.

Testing the validity of the test instrument was carried out on respondents with a total of 32 students, and the questionnaire instrument tested a total of 40 questions. The results showed that there were 25 invalid questions, with a value of r_{count} smaller than r_{table}. r_{table} = 0,349 with a significant level of 5%.

Table 1. Reliability Test Results

Test Type	Cronbach's Alpha	Reliability	Description
Pretest	0,807	0,7	Reliable
Posttest	0,807	0,7	Reliable

Good reliability is when the index is the same or higher than 0.7 (Litwin in Khumaedi, 2012). The Cronbach's alpha formula used in the reliability test calculated using SPSS obtained a reliability value of 0.807 for a total of 40 items. It means the test instruments of the pre-test and post-test were reliable to measure student learning outcomes.

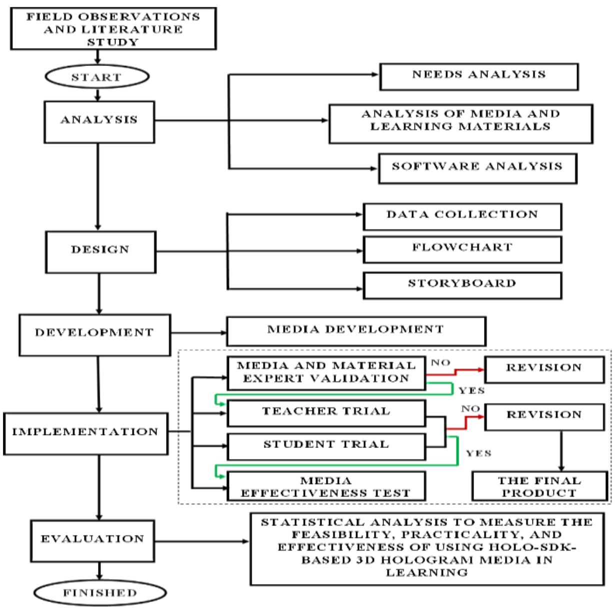

Figure 1. Research framework (storyboard)

Test instruments and questionnaires were used in collecting research data. Tests were needed to measure the success rate of the media in improving learning outcomes in the multimeter introduction measuring instruments carried out on students. The test given was the initial test before using the media (pretest) and the final test after using the media (posttest) in the form of a written test that contained multiple choice questions. The use of a questionnaire was necessary in order to determine the feasibility and practicality levels of the resulting product. This research questionnaire was in the form of a rating scale.

This research type contained quantitative data in the form of numbers from the results of media and material feasibility tests, the level of practicality of the media, and the level of effectiveness of the pretest assessment (before media use) and post-test (after media use). The qualitative data in this study were in the form of an assessment of the quality of the objects studied and were generated from suggestions, criticisms, and media responses.

Data feasibility assessment by expert validation and practicality of the benefits of media and media convenience ware based on the responses of teachers and students as users. Learning media was feasible and practical if expert validation assessments and user responses obtained a percentage of more than 68.01%.

Media effectiveness used the pretest mean score compared with the post-test mean score, with the t-test used to partially determine the effect of each independent variable on the dependent variable in measuring media performance. The analysis tool used the SPSS Statistics 26 application with statistical analysis of paired sample t-tests used to evaluate the effectiveness of a treatment, which is indicated by the difference in the average score obtained from the assessment results before and after treatment (Wibawa, 2020). Guidelines for decision making in paired sample t-tests were based on the significance value (Sig.) of the SPSS output results, namely if the value of Sig. (*2-tailed*) < (0.05), then there was an average difference between pre-test and post-test (Santoso, 2014). The N-Gain test was used to see an increase in student learning outcomes (Savinainen & Scott, 2002), presenting $(0,0)<(g)<(0,3)$ is a low category, $(0,3)\leq(g)\leq(0,7)$ is a medium category, and $(g)>(0,7)$ as a high category (Sundayana, 2014). Meanwhile, for the interpretation of the effectiveness used N-*Gain* percent (%), that is, if the percentage obtained is 56% to 75%, it is fairly effective, and (g)> 76% is effective (Hake, 1998). Before carrying out the t-test, the prerequisite test was needed to determine if the data was normally distributed using the normality test. The homogeneity test was also used to determine whether the population or sample in the study was homogeneous.

RESULTS AND DISCUSSION

Results

The 3D hologram learning media in this study is an AR desktop application containing material and practice questions with 3D hologram media to introduce a Holo-SDK-based multimeter measuring instrument. Development of learning media using 3D software blender, Unity, and Holo-SDK, which contain several menus, namely: (1) material menu which contains 3D objects from analog multimeters and digital multimeters along with an introduction to the multimeter section and simulation animations of measuring resistance, voltage, and current; (2) Quiz Menu, the button used to go to Google form, which contains several practice questions following the material in the media; (3) The Help menu, which contains general guidelines and specific guidelines for using the application; (4) The Developer Info menu, which contains information on the identity of learning media developers and additional material in the form of documents linked with Google Drive, which contains multimeter material to complement the material on learning media.

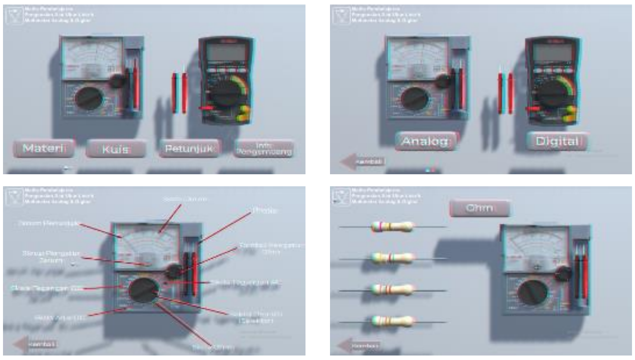

Figure 3. Display of Learning Media

The media and material feasibility tests are assessed by experts as expert validation to determine the quality of product feasibility and become material for product improvement before learning media is used by students. The feasibility test was carried out by submitting learning media and a questionnaire to media experts. Based on the suggestions and reviews of experts, several improvements need to be made. Reviews of suggestions/input from expert validation are presented in Tables 1 and 2. However, suggestions for adding digital electrical measuring devices from material experts were not added to the improvement due to the limited time for its development.

Table 2. Media Expert Suggestions and Revisions

Suggestion	Revision
The media manual lacks an explanation of general and specific uses	Addition of special and general instructions
Adjustment of the simulation with examples of calculations needs to be improved	Compatibility of simulation with calculations
The installation process should be simplified	Installation process made easy

Table 3. Material Expert Suggestions and Revisions

Suggestion	Revision
In the quiz in the first section, you can add the identity that fills in the quiz.	Adding identity to quizzes
Color combinations to make it even more interesting	The color combination has been adjusted.
Should be taught digital measuring tools	-

Statistical analysis to obtain feasibility has the criteria of "Very Feasible" or "Feasible", with the results of the expert validation sheet reaching more than 68.01% of the conversion of quantitative data obtained through the scores of each questionnaire item into the table of the percentage rating scale so that qualitative results are obtained. Media and material validation results are presented in Table 4 and Table 5.

Table 4. Media Validation Assessment Results

Aspect	% Per-aspect	Criteria	% Validation	Validation Criteria
Software	83.33 %	Feasible	91 %	Very feasible
Language	96.00 %	Very feasible		
Display	93.33%	Very feasible		
Graphic	93.33 %	Very feasible		

Table 5. Material Validation Assessment Results

Aspect	% Per-aspect	Criteria	% Validasi	Kriteria Validasi
Learning design	88. 67%	Very feasible	89.00	Very feasible
Visual display	88.33%	Very feasible		
Device engineering	90.00%	Very feasible		

In Table 4, the assessment results from the media expert validation are declared feasible, with a final validation result of 91%, indicating the criteria for a "Very Feasible" assessment. From Table 5, the assessment results from the material expert validation are declared feasible with a final validation result of 88.89%, indicating the "Very Feasible" assessment criteria. Learning media is suitable for use in learning activities from the results of expert validation assessments.

Statistical analysis is carried out to obtain a practical level having the criteria of "Very Practical" or "Practical" with the results of the expert validation sheet reaching more than 68.01%. The results obtained are in the form of quantitative data, along with criticisms and suggestions for improvements to the media. The teacher and student responses are shown in Table 6 and Table 7.

Table 6. Teacher Practical Results

Aspect	%	Criteria	% Practical	Praaacticality Criteria
Benefits	94.29%	Strongly agree	96 %	Very practical
Convenience	100%	Strongly agree		

The data in Table 6 results from the practicality test by the teacher on learning media is stated to be practical for use in learning activities with a final validation result of 96% with the "Very Practical" criteria.

Table 7. Student Practicality Assessment Results

Aspect	Result	% per-aspect	Category	% Practical	Category
Benefits	172 150 158	88.45%	Strongly agree	86.89%	Very Practical

Convenience	160 156 152 158 167 167 179	91.45%	Strongly agree

From the data in Table 7, the results of the practicality test by students are stated to be practical for use in learning activities, with a final assessment result of 86.89%. This average value can be included in very practical criteria.

The effectiveness of using instructional media is obtained from statistical analysis in measuring the effectiveness of media by comparing the pre-test and post-test mean scores. The acquired analysis of pretest and post-test scores is shown in Table 8.

Table 8. Analysis of Student Test Scores

Parameter	Pre-test	Post-test
Mean	36.67	78.75
Median	35.00	80.00
Standard deviation	8.944	11.915
Kurtosis	-0.506	-0.060
Skewness	0.321	-0.504
Range	35	50
Minimum	20	50
Maximum	55	100
Sum	1320	2825

Based on the data on Table 8, the description of the pretest results shows the mean value of 36.67, with a standard deviation (std) of 8.944, the minimum value of 20, the maximum value of 55, and the total value of 1320 of the total maximum ideal score of 3600. Description of the post-test results has a mean value of 78.47, With a standard deviation (std) of 8.944, the minimum value of 20, the maximum value of 55, and the total value of 1320 out of the total maximum ideal score of 3600.

The pre-test and post-test mean value results descriptively prove the difference in the average value of 41.80 before and after using the media. Furthermore, to prove the difference, a paired sample t-test is carried out; before that, a normality test had been carried out.

Table 9. Normality test

Learning outcomes	Test	*Shapiro-Wilk*		
		Statistic	df	Sig.
Before	Pre-test	0,955	36	0.150
After	Post-test	0,952	36	0.122

a. Lilliefors Significance Correction

From the calculation of the prerequisite test for the normality test in Table 9, because in this study, less than 50 samples, the researchers used Shapiro-Wilk, with a significant level of confidence α = 0.05 and a significant value obtained is 0.150 in the pretest value, it can be interpreted that the pretest data is normally distributed because sig pre-test > α. With and significant value for the post-test of 0.122, it can be concluded that the data is normally distributed.

Table 10. Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Learning outcomes	Based on Mean	1.972	1	70	0,165

Table 10 shows the homogeneity test results, which produce a significance value of 0.165 > (α), so the data from the student trials have a homogeneous variance. The average value of pre-test and post-test compared used statistical analysis of paired Sample t-test and the N-Gain Test.

Table 11. Paired Sample T Test

Value	t-test	df	Sig. (2-tailed)	t-table
Students' values before and after	19.840	35	0,000	2.030

The value is $t_{count}>t_{table}$, so it can be concluded that before use with after use of learning media, there appears to be a difference. It can be seen in the results *sig. 2-tailed* has a value of 0.000 <0.05. From these results, it can be concluded that there is a significant difference from the mean of the pre-test to the post-test, which means the use of 3D hologram-based on Holo-SDK learning media can provide differences in this results of the value in improving student learning outcomes in the multimeter introduction measuring instrument material.

Table 12. N-Gain Test

N-Gain	N	Min	Max	Mean	Std. Deviation
N Gain Score	36	0.31	1.00	0.6648	0.17858
N Gain percentage	36	30.77	100.00	66.4825	17.85788

The average analysis of the N-Gain test is 0.6648 < 0.7 from Table 12. The N-Gain criteria shows a moderate increase, which means that student learning outcomes have increased in the moderate category after using the media, while the N-Gain percent results show a value of 66.4825% which shows that Holo-SDK-based 3D Hologram learning media is fairly effective in improving student learning outcomes.

Discussion

Based on the research results, product development, data validity level, which is very valid, practicality which has benefits and convenience, and the effectiveness of Holo-SDK-based 3D hologram learning media for vocational student learning can improve student learning outcomes. In connection with previous research, the effectiveness of multimeter learning media has not been studied further. However, the application of multimeter learning media has been researched to make learning more interesting and clear and energy and time-efficient (Rahman, 2018; Suprapta et al., 2018; Yulanto et al., 2022). Holo-SDK-based 3D hologram learning media in the Fundamentals of Electrical Engineering learning process can improve student learning outcomes. According to research conducted by Lee (2013) and Turk and Kapucu (2021), using technology in media is a good way to provide solutions to learning problems that often occur. Besides that, it can help increase student motivation by developing a tool that allows equipment that is difficult to bring in for the needs of support educator explanations on the material in class and practice (Safitri, 2021).

The product in the form of an AR desktop application contains material, 3D object images, audio, animation, and practice questions, which can be accessed on the network and supports operation on Windows and Mac. This application is presented in the form of a document *.exe* compatible with a computer/PC. Presentation of material in the form of 3D object images with an explanation of the introduction of multimeter parts and simulation animations of use is accompanied by audio explanations for each type of multimeter which are made interactively by using the keyboard and mouse function keys to be able to zoom in, zoom out, rotate (turn) 360^{O}, and pan the 3D object so that students are actively engaged. The preparation of the material is adjusted to the development aspect and the Learning Outcome Elements. The material design flow in the application is presented in the flowchart format and a navigation structure to facilitate the preparation of material. Practice questions in online quizzes, namely by Google form, aim to train students' understanding. This research has an update with the use of Holo-SDK in implementing 3D hologram effects on AR desktops (Kim et al., 2014). (Lee, 2013) hologram media is an attractive and effective medium for enhancing student-centered learning, which allows students to interact with the media and build knowledge based on their direct learning experiences.

The study results show that the media has met the feasibilty requirements to be tested in the learning process according to RI Law No. 20 about the National Education System (2003) and Wahono (2006). The results of the assessment of the benefits and convenience of the media to determine the practicality of the media show that teachers and students strongly agree that the media is considered practical in the learning process. The results of the analysis of the N-Gain test on the effectiveness of the media show that the media is considered effective for increasing student scores after the use of media in learning, as evidenced by the paired sample t-test in the use of learning media has differences in learning outcomes before using media and after using 3D hologram learning media based on the Holo-SDK on the sub-element of the multimeter measuring instrument in the Basics of Electronic Engineering subject.

The limitations of this learning media development research are that the Holo-SDK-based 3D Hologram learning media is developed on just one material, namely the introduction and measurement of a multimeter by simulating resistance, current, and voltage measurements. Interactive media is in the form of scale, rotate, and slide. The product being developed requires 3D glasses as a tool to visualize 3D objects to become real. Holo-SDK-based 3D Hologram learning media can be operated with an internet connection. An internal or external camera is needed so that there are no errors in the operation of the media and camera functions to be able to track the user's head to be more interactive on the run. Determining the achievement of student learning outcomes only includes cognitive aspects.

CONCLUSION

The final product of developing 3D hologram learning media based on the Holo-SDK is an AR desktop application as a multimeter learning medium with sub-elements of multimeter parts and simulation in the form of animation. Based on the results and discussion, 3D hologram learning media based on the Holo-SDK in multimeter introduction materials is a feasible, practical, and effective medium for improving student learning outcomes.

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