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Utilizing Augmented Reality-Based Learning Media on Concrete Compressive Strengt Test Tool

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Abstract

Augmented Reality is a technology that can incorporate virtual objects in two or three dimensions into a real environment in real time. In the current Industrial Revolution 4.0 era, AR technology is widely used in the fields of games, medicine, and image processing, while it is rarely used in the field of education. The purpose of the present study is (1) to describe the process of developing learning media based on Augmented Reality in material technology course. (2) to produce learning media based on Augmented Reality on concrete compressive strength test material that is valid, practical, and effective. This type of research is research and development (R&D). The development process refers to the ADDIE development model which consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. The results showed that the average validity score of Augmented Reality-based learning media about concrete compressive test was 4.51 in the very valid category. Based on student response data, it showed that students had a positive response to the augmented reality-based learning media on concrete compressive strength test, showing a minimum of 89.96% or more students responding in the agree category, for each aspect that was responded to. Around 95.44% of students were able to achieve the value of learning completeness criteria so that the Augmented Reality-based learning media was categorized as effective.

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INTRODUCTION

Augmented Reality is widely used in the fields of games, medicine, and image processing, while in the field of education it is still rarely used. The development of technology and information is currently growing very rapidly. The learning process cannot be separated from the use of learning media which supports the learning process, computer technology has a very important role in helping solve problems in the field of education. One of the computer technologies currently being developed is Augmented Reality (AR) technology. Augmented Reality (AR) is a technology that combines two or three-dimensional virtual objects into a real environment and then projects these virtual objects in real time. According to Haller, Billinghurst, and Thomas (2007) Augmented Reality aims to develop technology that allows real-time merging of digital content created by computers with the real world. The learning method for the concrete compressive test used today is still conventional. The delivery of the material still uses media such as whiteboards along with pictures in books, so that students find it difficult to imagine the machine components that will be studied. Sari (2012) states that Multimedia presentations with Augmented Reality (AR) technology can be applied to replace conventional learning. Nincarean, Alia, Halim, & Rahman (2013) revealed that Augmented Reality (AR) is one of the developing technologies which has tremendous potential to improve the quality of learning.

According to Sari (2013) one of the causes of low student learning outcomes is the learning method used by teachers which only uses the lecturing method. It makes students unmotivated to learn. Related to this problem, teachers need to develop effective and efficient learning so that students understand lessons more easily and student learning outcomes will be more optimal. The development of Adobe Flash android-based learning media on conventional filing system is very effective, feasible and gets a high response from students (Adha & Hadromi, 2020).

The use of learning media should get the teacher's attention in learning activities. According to Saputro & Saputra (2014) learning media apparently follows the development of existing technology, starting from printing technology, audio-visual, computers to combined technology between printing technology and computers. Effects of Audio-Visual Media on Learning Outcomes in Subjects of Image Deprivation (Cahyono, Khumaedi, and Hadromi, 2021)

One of the benefits that can be drawn from the existence of this technology is that we can use it as an effective, creative, and educative learning media. Therefore, educational application media can continue to be developed, one of which is Augmented Reality (AR) technology. Suharso (2011) argues that the use of learning applications using AR technology can simplify the teacher's task in presenting material, shorten the duration of time required and can create a more interactive learning atmosphere. Apart from that, the advantage of this application is that it has high interactivity, namely the presence of AR virtual objects that can interact directly with users.

According to Buchori (2017) android learning media that can be selected according to geometric characteristics is android media using Augmented Reality. It is caused by the fact that Augmented Reality is a technology that combines two or three-dimensional virtual objects into a real three-dimensional environment in our environment and projects virtual objects in real time with an Android phone (Azuma, 1997). Saputro & Saputra (2014) define AR technology or also known as Augmented Reality, which is the integrity of digital elements that are added to the real world directly (real world data) and follow the existing environmental conditions in the real world and can be applied to mobile devices.

Utilization of Android Smartphones as an Effort to Increase Students' Creativity Capabilities in Learning Modern Hair Bun Courses at Vocational High School in the Pandemic Era (kecvara et al. (2021). According to (Buchori, 2017: 138) Android learning media that can be selected according to geometric characteristics are media Android uses Augmented Reality because Augmented Reality is a technology that combines two or three-dimensional virtual objects into a real three-dimensional environment in our environment and projects virtual objects in real time with an Android phone (Azuma, 1997).

Augmented Reality technology is a visual technology that combines virtual world objects into real-world displays in real time. By utilizing

Augmented Reality technology and an android smartphone, geometric objects can be visualized concretely through three-dimensional virtual modeling that is almost similar to the original object right above the concrete compression testing machine image on paper. For this reason, an Android-based application by utilizing Augmented Reality technology as a learning medium for material technology courses can be an alternative to assist students in understanding the concrete compressive testing process.

Based on this, it is expected that by using this application, students do not need actual practical tools to be used in learning, with the risk of damage to the component equipment and being able to increase the ease of learning for students. This is consistent with the results of the study that the Augmented Reality-based learning model which is used as a learning medium can create a new, more interactive atmosphere in learning [Siswanto (2013, Rusnandi (2015) & Burhanudin (2017))]. With the addition of interactive learning media it is hoped that Augmented Reality is expected to be used as an alternative learning media to introduce electronic components that can make students interested and enthusiastic in learning.

METHODS

This research is a type of Research and Development using the ADDIE model, namely the Analysis, Design, Development, Implementation, Evaluation stages (Adisasongko 2021). The research subjects were taken from students majoring in civil engineering at UNNES. The stages of media development with the ADDIE model can be seen more clearly in Figure 1 below:

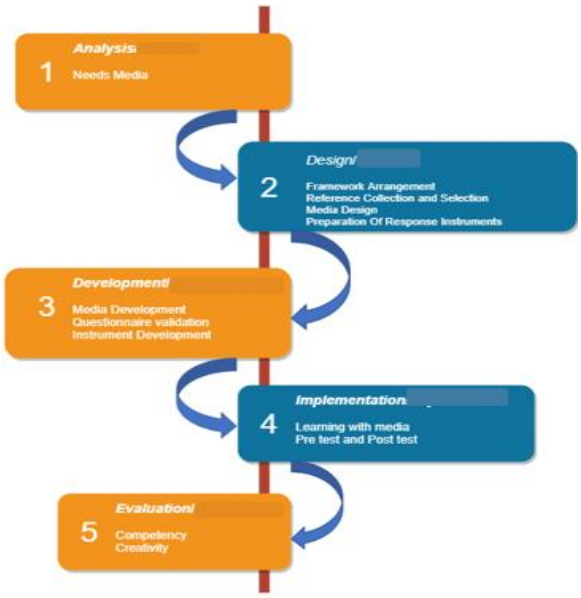

Figure 1. Media Development Procedures Using the ADDIE Model

RESEARCH PROCEDURE

1. Analysis

The initial stage carried out in this study was the analysis stage which consisted of two stages, namely performance analysis and needs analysis. In this stage the researcher conducted field observations by interviewing the lecturer concerned regarding learning process at the campus. From the results of the interviews, information was obtained that in the learning process the media used were in the form of teaching material modules and textbooks. The teaching material module also does not attract students' attention and interest because it only discusses material in general and there is a lack of supporting image visualization. From this problem researchers will develop learning media based on Android using Augmented Reality on concrete compressive strength test material.

2. Design

The second stage is the designing stage, at this stage the researcher will prepare and design the device by compiling: a syllabus that refers to the campus curriculum, semester learning plan (RPS), designing material for concrete compressive strength test procedures according to SNI standards (1974: 2011) Specifically carried out by adapting module held by students as well as designing android applications, making expert validation sheets for product assessment, making student

response questionnaires to products, evaluation questions, exam content outline, answer keys and question scoring rubrics. At this stage, the researcher produces a product design where the researcher designs the initial product that will be made for researching and designing an Android-based Augmented Reality application.

3. Development

The third stage is the Development stage, in this stage product validation is carried out by the validator. In this study, there were 2 categories that were validated including media expert validation and material expert validation. The validators appointed as media experts were one lecturer from Visual Communication Design (D3) majoring in fine arts FBS UNNES and one lecturer from the Department of Civil Engineering FT UNNES. In this stage, the researcher produces validation results by the media validator which is the reference for researcher to improve the product. The validators who were appointed as material experts were two lecturers from the Department of Civil Engineering FT UNNES who taught materials technology course and 5 lecturers majoring in Civil Engineering UNNES. Where researcher also produced validation results by material validators which will later become a reference for improving the product he made. From the results of the validation by the two categories of experts, the researcher was able to find out the advantages and disadvantages of the product, and later it will be corrected by the researcher before being tested. Then, after improving the product that has been validated by experts, the researcher produced a product that was feasible and ready to be used for learning process to be researched.

4. Implementation

The fourth stage is the implementation stage. In this stage the researcher implemented or applied the media design that has been developed in a real situation, namely the experimental class. Researcher guided students to achieve learning goals and solutions to overcome gaps in learning outcomes.

5. Evaluation

The fifth stage is the evaluation stage, in this stage the researcher conducted a final test in the form of a post test at the last meeting to find out student learning outcomes after carrying out learning using Android-based Augmented Reality learning media.

This research was conducted at the Department of Civil Engineering, Universitas Negeri Semarang. The sample in this study were civil engineering students in fourth semester Class 1 as the experimental class and Class 2 as the control class. This research was conducted on June 18 2022. Apart from students, civil engineering lecturers in this study were also the subject of research. Research procedures are steps that researchers do during research. This research procedure includes the stages of preparation, implementation, conclusions, and research result report.

The products of this research were assessed on three things, namely validity, practicality, and effectiveness. The validity assessment instruments include the RPS validation sheet, and the Android-based Augmented Reality application validation sheet. The practicality instrument uses student assessment sheets on the material for concrete compressive strength test procedures and android applications. The effectiveness assessment instrument was carried out to find out the difference between learning using media and conventional learning.

The validity and practicality sheet of this instrument uses a scale range of 5, namely strongly agree, agree, neutral, disagree and strongly disagree. The data is converted into qualitative data using the following criteria:

Table 1. Percentage Range and Program Quantitative Criteria

No	Interval (%)	Criteria
1	81 - 100	Very Good
2	61 - 80	Good
3	41 - 60	Acceptable
4	21 - 40	Poor
5	0 - 20	Very Poor

Effectiveness data was obtained from the experimental class and control class learning outcomes tests. The data of each class was tested for its effectiveness using the right-tailed t-test. Furthermore, learning completeness test was carried out to determine student success after learning with

Augmented Reality media for the experimental class and conventional learning for the control class.

Before testing the effectiveness, an assumption (prerequisite) test is carried out, namely the data normality test and the variance homogeneity test. The normality test is intended to test whether the data obtained comes from a normally distributed population or not, so the normality test is used. The normality test in this study used the Kolmogrov Smirnov and Shapiro-Wilk tests. After the prerequisite test is fulfilled, then the t-test is carried out. All tests are carried out with the help of the computer program SPSS Version 16 for windows.

RESULT AND DISCUSSION

The results of the research presented consist of several things including: the results of Augmented Reality development media, the results of validity and reliability tests, and the results of trials on respondents. The following is a presentation of the results of AR development media.

a) Application Logo

Figure 2. AR SARCoM. (Apk) Application Logo

b) Application Marker

Figure 3. Application Marker

c) Main Menu Scene

Figure 4. Main Menu Scene

Based on Picture 4, it is known that in this scene there are 4 buttons that have different functions, namely: the start button to start the application, the Material menu to be used to view the material to be studied, the About application button to explain the application maker, the X button to end the application.

d) Camera to AR Marker Scene

Figure 5. Camera to AR Marker Scene

This AR camera menu is used to identify markers using Smartphone camera.

e) Augmented Reality application design menu scene

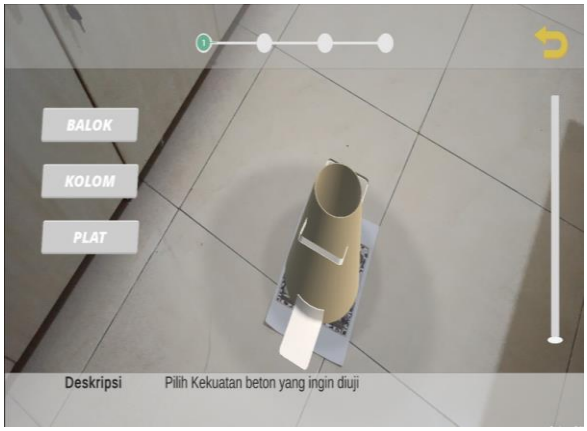

Figure 6. Augmented Reality application design

Validity Test Results

There are 2 categories that are validated in android-based learning media using Augmented Reality, media expert validation and material expert validation. Media experts validate the concrete compressive strength test material and android application, material experts validate the concrete compressive strength test material contained in the material technology module and android application.

The validators for media experts are 2 lecturers at Universitas Negeri Semarang, each lecturer from Visual Communication Design study program (D3) majoring in fine arts FBS UNNES and Civil Engineering study program majoring in Civil Engineering FT UNNES. The material expert validators are 2 lecturers from the Civil Engineering Study Program majoring in Civil Engineering FT UNNES.

Table 2. Media Expert Feasibility Test Results

Feasibility Indicator	Media Expert		Mean	Category	(%)
	1	2			
Presentation design	27	28	27.5	Very Feasible	91.67
Interaction Usability	23	23	23	Very Feasible	92
Accessibility	45	43	44	Very Feasible	88
Reusability	35	35	35	Very Feasible	87.5
TOTAL	130	127	128.5	Very Feasible	89.79

The results of the feasibility of learning media from media experts seen from the feasibility of each aspect show that the Interaction Usability Indicator occupies the highest score. It is 92% on a very feasible scale.

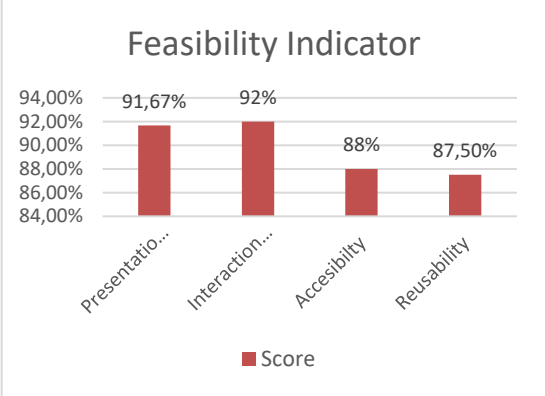

Figure 7. Media expert Feasibility Test Results

Table 3. Material Expert Feasibility Test Results

Feasibility Indicator	Material Expert		Mean	Category	(%)
	1	2			
Content Quality	19	19	19	Very Feasible	95
Learning Goal	22	21	21.5	Very Feasible	86
Accessibility	20	20	20	Very Feasible	100
Reusability	9	8	8.5	Very Feasible	85
feedback and Adaptation	13	13	13	Very Feasible	86.67
Motivation	19	18	18.5	Very Feasible	92.50
TOTAL	102	99	100.5	Very Feasible	90.9

After conducting expert validation, the development of android-based learning media using Augmented Reality on concrete compressive strength test material was then revised according to the validator's criticisms and suggestions before conducting product trials. Based on the results of the discussion from the expert validation, it can be concluded that android-based learning media using Augmented Reality on concrete compressive strength test material is valid and feasible for dissemination.

Based on the results of the assessment of 2 Material Experts, a total score of 100.50 was obtained while the expected total was 110, so the total score was calculated by the percentage of eligibility of Augmented Reality Application-based learning media in Material Technology for making concrete compression test equipment by Material Experts was 90 .9%. It was in the very feasible category.

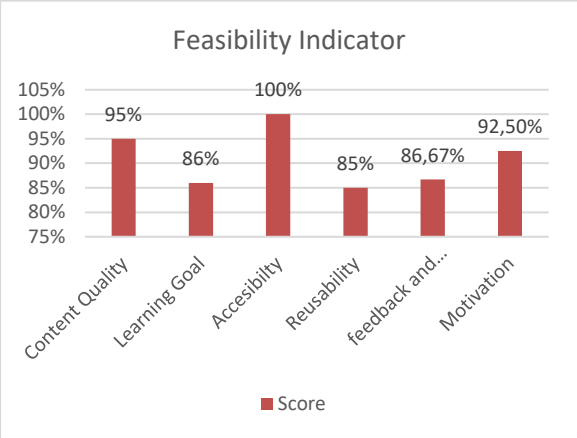

Figure 8. Material expert Feasibility Test Results

Practicality Test Result

Based on the results of the assessment of 2 Lecturers in the Materials Technology course, a total score of 149.5 was obtained while the expected total was 160, so the total score was calculated by the percentage of suitability of learning media for the Application of Augmented Reality in the theoretical course of material technology for concrete compressive strength testing which was 93. 44%. It was in the Very Appropriate category, while the calculation of each lecturer questionnaire indicator is as follows:

Table 4. Media Practicality Test Results by Lecturers

Indicator	Lecturer		Mean	Category	%
	1	2			
Content Quality	19	19	19	Very Practical	95
Learning Goal	23	22	22.50	Very Practical	90
Feedback And Adaptation	18	18	18	Very Practical	90
Motivation	20	20	20	Very Practical	100
Presentation design	21	21	21	Practical	84
Interaction Usability	15	13	14	Very Practical	93.33
Accessibility	20	20	20	Very Practical	100
Reusability	15	15	15	Very Practical	100
TOTAL	151	148	149.5	Very Practical	94.04

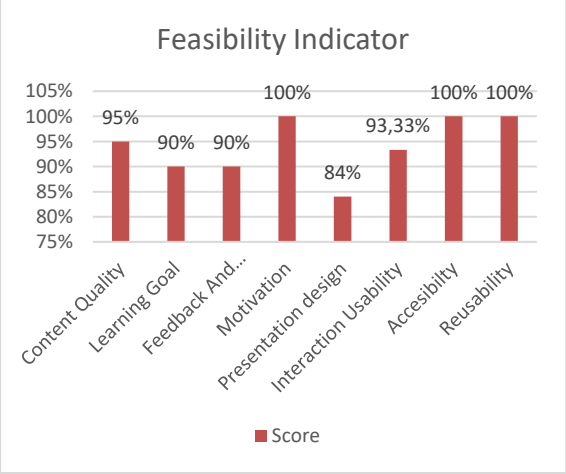

Figure 9. Practicality test results by lecturers

Furthermore, student responses through learning media were given to 30 students of the Experimental Class 1 to assess the feasibility using a student questionnaire. The results of student assessments of learning media are as follows:

Table 5. Media Practicality Test Results by Students

Indicator	Total	Skor Rata-rata	Category	Percentage Score
Content Quality	859	19.09	Very Feasible	95.44
Learning Goal	1012	22.49	Very Feasible	89.96
Feedback And Adaptation	625	13.89	Very Feasible	92.59
Motivation	622	13.82	Very Feasible	92.15
TOTAL	3118	69.29	Very Feasible	92.54

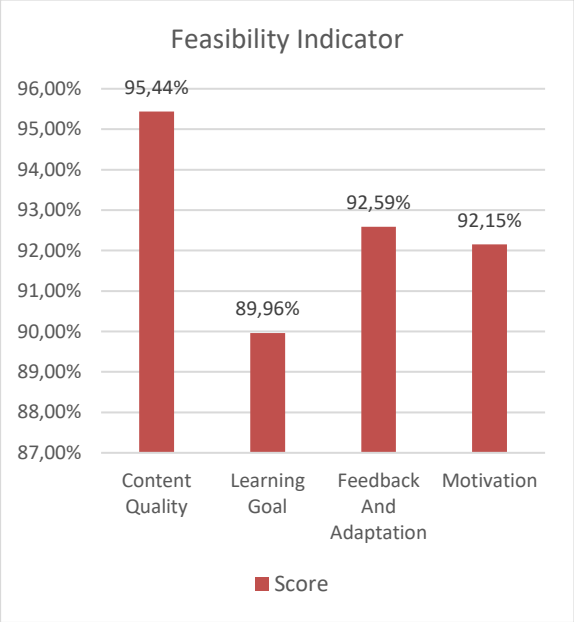

Figure 10. Practicality test results by students

Based on the results of the assessment of 30 students majoring in civil engineering at UNNES, an average score of 69.29 was obtained in the very appropriate category. The total score of the student questionnaire evaluation is calculated by the percentage of suitability of concrete compression test tool making learning media is 92.39%.

Evaluation Assessment of learning media was carried out through a questionnaire given by 30 students based on 4 assessment indicators consisting of aspects of Content quality, Learning goals, Feedback and adaptation, and Motivation. The results of the data obtained showed that the highest aspect was Content quality, which was equal to 95. 44%, then Feedback and adaptation 92.59%, Motivation aspect 92.15%, and finally Learning goal aspect 89.96%.

Based on the results of student responses, it can be concluded that android-based learning media using Augmented Reality on concrete compressive strength tests are practically used. Mustaqim (2016) revealed that the use of Augmented Reality is very useful for interactive and real learning media directly by students. According to Antonioli, Blake, & Sparks (2014) Augmented Reality (AR) has proven to be an interesting way for students to participate in their learning. These new technologies enable student-centered learning and create opportunities for collaboration that foster a deeper understanding of material.

Effectiveness Test Results

Data on student learning outcomes described in the present study consist of initial data and final data. The initial data was obtained from the results of the pretest scores and the final data were obtained from the posttest results. In summary, descriptions of student learning outcomes in the control and experimental classes are presented in table 6.

Table 6. Data Normality Test

Tests of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.142	30	.127	.944	30	.114
Posttest	.162	30	.044	.948	30	.149

Based on the results of normality test calculations using the Shapiro-Wilk test, it can be seen that the pretest significance value is 0.114> 0.05 and the posttest is 0.149> 0.05, so that the data can be said to be normally distributed.

The results of the homogeneity test of the pretest and posttest data were calculated using SPSS 16, it was found that the significant value of the pretest and posttest data was 0.369. From the homogeneity of the pretest and posttest data, the significance value is greater than 0.05, so the data can be said to be homogeneously distributed. The homogeneity test results can be seen in table 7.

Table 7. Homogeneity Test

Learning Outcomes			
Levene Statistic	df1	df2	Sig.
1.162	6	18	.369

So it can be concluded that the initial data for the class and the final data for the experiment and control class are normally distributed and homogeneous.

After it is known that both classes of initial data and final data are normally distributed and homogeneous. Then a t-test will be carried out to find out whether student learning outcomes after using Android-based learning media using Augmented Reality are better than conventional learning. The results of the t-test are presented in Table 7.

Table 8. T Test

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-Test & Post Test	30	.712	.000

Based on the t test, a significance value of 0.000 <0.05 was obtained, so it can be concluded that there is a significant difference between the scores of student learning outcomes before and after the use of learning media. In order to find out how effective learning media based on Augmented Reality Applications on theoretical subjects of the material technology for making concrete compression test equipment, the N-Gain Test was used according to research by Adisasongko et al., (2021) with an average N-Gain score of the product 71.34% or quite effective. The results of the calculation of the N-Gain Test can be seen in table 9.

Table 9. Uji N-Gain

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain_score	30	.55	.93	.7728	.09630
N-Gain_Percentage	30	54.55	93.33	77.2845	9.63005
Valid N (listwise)	30				

Based on the N-Gain Test, it is known that the average value is 77.2845 or 77.28% It belongs to the effective category with a minimum N-Gain score of 54.55 and a maximum of 93.33.

Based on the results and discussion, it can be concluded that "Development of Android-based learning media using Augmented Reality on concrete compressive strength test material" is feasible for use in learning activities according to media experts, material experts, civil engineering lecturer responses and student responses, and from the learning outcome. In addition, Android-based media using Augmented Reality on concrete compressive strength test material is better than learning outcomes with conventional learning.

Discussion

From the results of data analysis, it can be seen that the development of Augmented Reality learning media applications is feasible for use in material technology courses [Baharudin (2017), Mareta (2015)].

Research by Kurniadi (2019:146-157) Development of Augmented Reality-Based Network Hardware Learning Media on the Android Platform. This study aims to make learning media for WAN technology network hardware due to the limited tools in the school laboratory during practicum. The results showed that based on the feasibility test, this learning media was very practical (95.45%) and very valid (94.7%). The relevance of this research to the present study is the use of the Marker Based Tracking Method in Augmented Reality technology to display three-dimensional (3D) objects on Android Smartphones. Network device 3D objects are designed using the Blender application.

Research by Sidik (2021:14-28) Implementation of Augmented Reality Technology in Android-Based Interactive Learning Media for Computer Network Installation Materials. The research objective is to develop Android-based

learning media equipped with Augmented Reality technology to assist the learning process. The results of the study show that testing by media experts covering aspects of interface design and instructional design shows a score of 78% in the feasible category. Tests by material experts covering aspects of material content and presentation of material as well as feedback showed a score of 84.1% in the very feasible category. Tests by Respondents (users) covering aspects of display design, navigation and presentation of material show a score of 88.96% with a very feasible category. The relevance of this research to the present study is that the research method used is the Research and Development (R&D) method with the adaptation of the ADDIE development model.

Research by Pelealu et al (2018:1492-1499) Research by Pelealu et al (2018:1492-1499) Development of Augmented Reality Mobile Educational Games to Help Children Learning on Reading, Writing, and Counting. This research aims to develop augmented reality technology to be used so that games are more interesting for children and are expected to attract children's interest in learning. The results of the study were obtained during the pre-test with reading, writing, and arithmetic questions when compared to the post-test scores with the same questions which increased and this showed that the games could influence them in the concept of reading, writing, and arithmetic to children. The influence of games on children's reading, writing, and arithmetic concepts was increasing after the pre-test average was obtained. The average pre-test score was 76 and the post-test average was 80. The relevance of this study the present study is the development of Augmented Reality media to increase student learning interest.

Research by Sumbawati(2020:153-161) Development of Augmented Reality-Based Learning Media in Digital Systems Courses at the Unesa Informatics Engineering Department. This study aims to develop learning media based on Augmented Reality in digital systems courses on logic gates, so that students are able to study independently without being limited by space and time and to increase student interest in learning. The results of the research that has been carried out are: (1) Student responses after using learning media with digital Augmented Reality systems show good results of 88.75% in the "Very Eligible" category; (2) The results of the material feasibility assessment by material experts get a percentage of 91.07% in the "Very Feasible" category. The feasibility assessment by media experts got a percentage of 91.4% in the "Very Feasible" category. Thus, this digital system Augmented Reality learning media can be used in learning with the "Very Feasible" category. The relevance of this research to the present is the development of learning media based on Augmented Reality to increase students' interest in learning.

From the results of previous research as described above, there are some similarities with the present study, namely the development of learning media based on Augmented Reality technology and the type of research. However, from that research, nothing is really the same as the problem that was examined in the present study. The novelty of the present study is that the use of Augmented Reality media applications by students majoring in Civil Engineering, Universitas Negeri Semarang can be categorized as very feasible, very practical, effective and significant for increasing student competence and creativity. The novelty in the present study is the development of Augmented Reality application media which is used as a guideline in learning concrete compression testing digitally, media in the form of electronic media which makes it easier for students to learn independently, there are coherent work steps accompanied by colorful pictures, can be applied directly to mobile phones by students and lecturers majoring in civil engineering and practitioners.

The way this application works is that if the material containing the AR application is opened, it will open the camera on the device installed on the smartphone. The use of this camera is to detect markers contained in the material section, if the camera succeeds in tracking the marker it will display a 3D image.

In the present study, 6 indicators are made as a reference whether this application is feasible to use or not. The results of the validity showed 89.79% of the 45 questions and 5 items were invalid, so that 40 questions were eligible to be used and included in the valid category. Based on the reliability test, the media got the score of 0.802 or 80.20%, it means that the media is reliable to use. Likewise, the results of product trials conducted on students showed that student responses indicated that the AR application

was feasible to be used in materials technology courses with an overall percentage result of 92% and can be interpreted as valid and very feasible to use.

The development of material technology learning media (making concrete compressive strength test tool) uses the Augmented Reality Application program which produces applications that can run on computers or laptops and Android-based mobile phones. This Augmented Reality Application-based learning media can run without having to install other additional software, so it is very easy to use.

The application of Augmented Reality learning media is able to provide an interactive learning atmosphere for students because they are able to understand learning material in more detail and thoroughly, [Hermawan (2015), Mantasia (2016)]. The advantage of Augmented Reality learning media that is applied in material technology courses is that it can provide stimulation to students' mindsets that learning does not always have to be conventional but can be fun and not boring by implementing learning activity that can display 3D based on simulation. In addition, the development of AR technology can meet the needs of improving students' creativity and cognitive skills and make it easier for students to understand something abstract and complex.

CONCLUSION

Based on the discussion of the present study, it can be concluded that the Augmented Reality learning media for concrete compression test tool can be used as a learning medium for concrete compressive strength test material which is able to provide convenience for students to understand the material. Augmented Reality learning media can be used as a fun learning medium and is able to create a new and interactive atmosphere in Civil Engineering student learning. Students' response to the Augmented Reality application is very high which can increase students' enthusiasm during the learning process. It can be said that the Development of Android-based Learning Media using Augmented Reality is effective.

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