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Designing Interactive Multimedia-Based Learning Media Using Augmented Reality in Basic Computer and Networking Subjects Computer and Basic Networking for School Expertise Package Vocational High School

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ABSTRACT

Learning infrastructure is one of the supporting factors for vocational high school learning activities for the Computer and Informatics Engineering expertise program. Less effective learning media used by teachers as well as understanding and activeness of students in the learning process of this research background. The main objective of this research is to design and implement interactive multimedia based on Augmented reality with Auditory, Intellectually, and Repetition (AIR) learning models to determine the cognitive enhancement of students in learning network topology on basic computer and network subjects. Augmented reality-based interactive multimedia uses a comprehensive life cycle development model (SHM) and the research method used is quantitative with a sample of class X (ten) Multimedia students of SMK Negeri 1 Cipatat. From this research, the results obtained: (1) interactive multimedia is good and suitable for use. Obtained media value of 82% and material of 90.74% which is very well interpreted by media experts and subject teachers. (2) Interactive multimedia can improve students' cognitive with the acquisition of an average value of 0.697 with criteria that have "medium" criteria. (3) the students responded to the interactive multimedia learning media based on Augmented Reality, which was quite good, with a value of 80.24% and included in the "very good" category.

1. INTRODUCTION

Computers were originally created to help humans in the calculation process which was intended to replace manual calculators. In its history, the world's first computer was ENIAC (Electronic Numerical Integrator and Computer) which was created precisely in the United States in 1945. The development of computers from time to time allows computers to be connected to each other which is called a computer network (network). In 1969 the Advanced Research Projects Network (ARPANET) was developed by the Department of Defense (DOD) so that several computers could be connected to form a computer network. After going through many discoveries in the 1970s technological developments, the computer network by ARPANET not only connects between two computers but up to 10 computers so that these computers can communicate.

Computer networks then continued to develop and became the beginning of the creation of the idea of an international network, this idea was presented by 2 computer experts Vinto Cerf and Bob Kahn, who at that time called their idea presented at Sussex University. So each of these computer units can be interconnected and share information and data around the world. This makes distance no longer an obstacle in communicating through computers, in the world of education often combines the learning process and the use of technology that has developed over time.

Learning is created because of the process of interaction of students with teachers and learning resources in a learning environment, learning activities are the main thing in shaping quality human resources. But improving the quality of education cannot work without educator innovation. To improve the quality of education, various innovations are needed in the field of education, especially in terms of learning resources. These innovations must be adapted to the development of science and technology so that graduates can benefit the community.

Science and technology continue to develop following the times and bring influence to various fields, especially the field of education, in this case learning media cannot be separated from technology that helps the learning process. Learning media can utilize a variety of technologies such as still images, text, video, animated images, and the sense of hearing in this case referred to as multimedia. Multimedia technology has promised great potential in changing the way a person learns, obtains information, customizes information and so on (Husna & Pinem, 2011). Multimedia is a combination of various kinds of media which can be text, images, graphics, sound, animation, video, interaction, and others that have been packaged into digital files and can be used to convey information to the public.

Vocational high schools (SMK) in Indonesia currently use the national curriculum or the 2013 curriculum which requires students to be independent in learning. In a preliminary study conducted at a vocational high school in West Bandung Regency located in Cipatat in the 2020/2021 school year through an interview method with the teacher with the interview title "Obstacles to learning basic computers and networks in network topology material" it was found that the obstacles experienced in the difficulty of learning basic computers and networks, especially network topology material, include limited supporting infrastructure and lack of flexible learning media and unattractive models/images that are only depicted through black and white images, making it difficult for students to understand these images. This problem makes learning less than optimal. In general, schools provide computers but are limited and used by many classes, not only Multimedia classes but all classes use computer laboratories. Another way can be done with animation through a projector using power point learning media but in schools the projector for each class is usually not available because it is

damaged or limited. In its use, students tend to pay less attention to the media in the power point, because the power point is limited to the interaction of students with the media used, resulting in less optimal learning because of the problem of lack of motivation to pay attention to the material presented.

This multimedia technology continues to develop and utilizes various kinds of media and combines them into one called interactive multimedia. Interactive multimedia itself can be defined as an integration of several media elements (audio, video, graphics, text, animation, etc.) into a synergistic and symbiotic whole that produces more benefits for end users than one of the media elements can provide individually (Praheto *et al.*, 2019). The selection of the right device in learning media has a big effect on the learning process, smartphones are devices with growing rapidly in Indonesia, even projected that the number of gadget penetration in Indonesia will exceed the number of Indonesians. Indonesia is the fourth most populous country in the world reaching 260 million people, certainly a large digital technology market. Digital research institute predicts that in 2018 there will be an increase in the number of active users of smartphones in Indonesia, reaching more than 100 million.

One technology that can be developed in smartphones is Augmented Reality. Augmented Reality is an application of combining the real world with the virtual world in the form of two dimensions or three dimensions projected in a real environment at the same time (Saheltian & Helilintar, 2017; Sidiq, 2021; Maesaroh *et al.*, 2021). The use of Augmented reality is very useful in improving the process and interest of students in learning because Augmented reality itself has entertainment aspects that can increase interest in learning and playing and projecting it in real time (Mustaqim, 2016).

In this study, the authors are interested in Augmented reality technology because with this technology it is expected to facilitate student learning in the computer engineering and informatics expertise program in basic computer network subjects on network topology material.

2. METHODS

In this research, researchers fully refer to the comprehensive life cycle (SHM) because the purpose of this research is to produce an Augmented Reality-based interactive learning media product. In this study there are five stages of research procedures in accordance with the procedural, namely analysis, design, development, implementation, and assessment, which is described by a flowchart as shown in **Figure 1**.

Contains a clear description of the study or research results associated with the formulation of the problem and the results of similar previously published research. Discussion of the results of the study or research is described in this section. The rules for referencing are the same as those described in the introduction.

(i) Analysis stage. This stage is the process of analyzing the use of learning media based on the results of interviews with teachers and distributing questionnaires to students. The needs analysis stage consists of:

a) Literature review. Literature study by conducting theoretical studies through books, journals and other sources of information related to the learning media to be developed.

b) Field studies. At this stage, a questionnaire is given containing questions to get information about learning difficulties in basic computer and network subjects as well as knowing students' interest if the delivery of material through Augmented reality applications.

c) User analysis. User analysis is carried out to find out whose targets will use this media. this needs to be done because it will be one of the considerations in application design design activities.

d) Software analysis. Analysis of the software is done to find out what needs must be available in the software to be made. Other considerations for software are also adjusted to the hardware used for making applications and the use of these applications in the field.

(ii) Design stage. This stage is the stage of designing a learning media system model based on the results of the review in the first stage (analysis). The planning stage includes 4 stages, namely making flowcharts, storyboards, materials, and questions.

a) Flowchart. Flowchart is a chart consisting of certain symbols that show the steps of a procedure or program.

b) Storyboard. Storyboard is a visualization in the form of images along with other information about the media to be developed.

c) Material. Designing the material to be delivered in accordance with the learning model that will be used, namely the AIR (Auditory, Intellectually, and Repetition) learning model.

d) Questions. Designing pretest and posttest questions that will be given in accordance with the material that has been delivered.

(iii) Development stage. At this stage, the development of interactive multimedia is adjusted to the design that has been made which includes making applications, making materials, compiling magic books, and combining and testing prototypes.

(iv) Implementation stage. Testing is carried out by users, media experts, and material experts to determine the feasibility of applications that have been developed as well as user responses and assessments after using the media. From these results it can be seen whether the media is suitable for use.
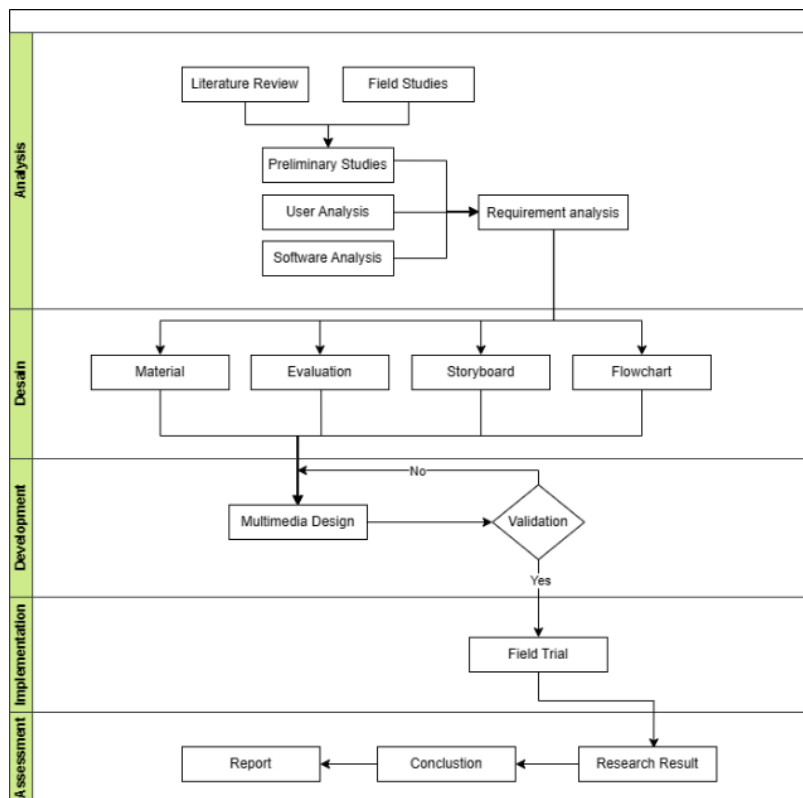

Figure 1. Flowchart design of research procedure.

Assessment stage. The assessment is carried out by media and material experts to determine the feasibility of multimedia that has been developed as well as the results of student responses after using interactive multimedia. From these results it can be seen whether the multimedia is suitable for use. In addition, the assessment stage is needed to improve and refine this multimedia to make it more perfect.

2.1. Research Design

The research design that the authors used in this study was a pre-experimental design (Nondesign) with the form of One-Group Pretest-Posttest Design. This design uses a pretest before treatment. Therefore, the results after treatment will be more accurate, because it can see the results of the comparison between after and before treatment. The One-Group Pretest-Posttest design procedure can be seen in **Table 1**.

Table 1. One-group design

Pretest	Treatment	Posttest
O_1	X	O_2

Description:
O_1 = Pretest value (value before given treatment)
X = Acceptable treatment
O_2 = Posttest value (value after given treatment)

The population in this study were vocational students who studied computer network topology. The sampling technique used in this study was carried out by nonprobability sampling type purposive sampling, which is a sampling technique with certain considerations with the consideration that the selected sample is in accordance with the problems raised by the researcher, then testing the learning media to all students of SMK Negeri 1 Cipatat class 10 Multimedia 1 which amounted to 22 students.

2.2. Research Instrument

The instrument used in this study is: a field study instrument which is a semi-structured interview done to a teacher; Instruments of which are clusters of multiple choice; The media validation instrument is using lori (learning instruments review instruments); and student responses instruments are student assessments and students' responses to learning using multimedia.

2.3. Analysis Instrument

Data analysis obtained from field studies can be directly described because they are the results of interviews. The instrument's data results are drawn from the testing of the students first, and then it will be done an instrument analysis of the validity, religious ability, hardship index, and problem deformity. Data analysis of the expert validation instruments and student response instruments USES the scale rating. Furthermore, the level of learning media validation in this study is categorized in four categories using a scale such as **Figure 2**.

Figure 2. Category interval results from expert validation responses.

N-gain test analysis aims to know increased student understanding capabilities. The calculations are derived from the average value of pretest and posttest. Next n-gain will be classified at **Table 2**.

Tabel 2. Gain test table

Gain Value (g)	Criteria
$0,00 < g \leq 0,30$	Lower
$0,30 < g \leq 0,70$	Medium
$0,70 < g \leq 1,00$	High

3. RESULTS AND DISCUSSION
3.1. Needs Analysis Results

The initial stage in designing and building interactive multimedia based on Augmented reality, researchers made initial observations which included field studies and literature studies. The field study that researchers conducted was by conducting an interview process with teachers who taught computer network subjects and distributing questionnaires to students at SMK Negeri 1 Cipatat. The problems encountered according to the results of interviews with educators who teach these subjects are:

(i) Learning methods in the classroom mostly use the lecture method, and use power point.
(ii) Facilities for practicum are very limited which makes practical learning time less.
(iii) Network Topology material in Computer Network subjects still has a vehicle that is not understood by most students.

Based on the results of interviews and the distribution of questionnaires above, innovation is needed to assist the learning process that can be used by students, with the help of interactive multimedia based on Augmented reality which is expected to make students' cognitive increase. Therefore, Augmented Reality-based interactive multimedia with AIR (Auditory, Intellectually, and Repetition) learning model is approved.

3.2. Interface Development

The following are the results of the Augmented reality-based interactive multimedia development that has been completed based on the flowchart and storyboard references.

3.2.1. App home view

In this case the application has an AR (Augmented reality) topology, and the application icon is purple and has an rj45 logo as the identity of the application. The AR topology icon can be seen in **Figure 3**.

Figure 3. App icon display.

3.2.2. Main menu

In the main menu, users can see various options, namely start, instructions, about, information, mute and quit buttons. The button display is animated and there is a musical backsound. The main menu page can be seen in **Figure 4**.

Figure 4. Main menu.

3.2.3. Question material menu

On this menu there are 5 options for the menu to the existing sub menu, namely mulai AR, KI-KD, materi, soal, tujuan, and button kembali. The menu selection page is presented in **Figure 5**.

Figure 5. Menu.

3.2.4. Material option menu

On the material choice menu there are 2 buttons, each of which goes to the sub menu, namely the network button for the network tool material menu and the topology material button to go to the topology material selection menu and the back button. The material selection menu page can be seen in **Figure 6**.

Figure 6. Select material menu.

3.2.5. Materi topologi option menu

In this menu there are 9 choices of topology material that will be studied by users this menu is also directly connected to the Augmented reality interface. The topology material selection page is presented in **Figure 7**.

Figure 7. Topology material selection menu.

3.2.6. Network tool material

The network tools menu is a summary of the previous material which is intended to strengthen the network topology material and as a repetition of material for students. In this menu users can swipe the screen left and right. The network tools page is presented in **Figure 8.**

Figure 8. Network tool material.

3.2.7. Network topology material

In the network topology material menu there is an option to go to AR (Augmented reality), other material options and topology video shortcut options. In this menu users can swipe the screen left and right. The network topology material page is presented in **Figure 9**.

Figure 9. Network topology material.

3.2.8. Augmented reality topology menu

It is a shortcut menu if the user wants to directly use Augmented reality, in this menu consists of 9 choices. This page is presented in **Figure 10**.

Figure 10. Augmented reality topology menu.

3.2.9. Interface augmented reality

In the Augmented reality interface, there are back button instructions and shortcuts to the material menu. In its use when the object is scanned it will bring up the sound. This page is presented in **Figures 11** and **Figure 12**.

Figure 11. Augmented reality.

Figure 12. Interface augmented reality.

3.2.10. Tutorial menu

Is an additional menu for how to use Augmented reality this menu is used to introduce Augmented reality. The tutorial page is presented in **Figure 12**.

Figure 12. Tutorial.

3.2.11. Quiz and practice menu

This menu has 2 options, namely quiz options which will be used to train students before taking tests and practice tests that go to google forms to determine the level of student abilities. The quiz select page is presented in **Figure 14**.

Figure 14. Quiz and practice menu.

3.2.12. Quiz menu

In this quiz menu there are 10 randomized quiz questions and there are 5 multiple choices. In this quiz, students are given 5 minutes. The quiz page is presented in **Figure 15**.

Figure 15. Picture quiz.

3.2.13. KIKD menu

Core competency and basic competency information used to explain the beginning of learning. The core competencies and basic competencies page is presented in **Figure 16**.

Figure 16. KIKD menu.

3.2.14. Learning objectives menu

This is learning objective information used to explain the beginning of learning, explaining the purpose of learning network topology. The learning objectives page is presented in **Figure 17**.
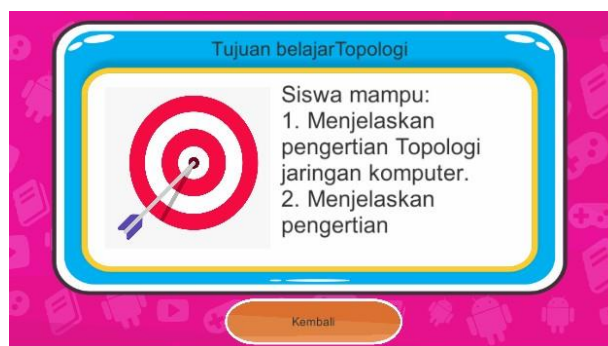

Figure 17. Learning objectives menu.

3.2.15. Application information menu

Application information is a menu that informs the application created and information on the purpose of this application. The application information page is presented in **Figure 18**.

Figure 18. Application information menu.

3.2.16. Builder app menu

Augmented reality application maker information which includes a photo and a brief profile of the application maker. The application creator page can be seen in **Figure 19**.

Figure 19. Builder app menu.

3.3. Expert Validation Test Results

This validation test is to test the feasibility of interactive multimedia that has been developed as validation and verification by experts. This validation test refers to the LORI (Learning Objects Review Instrument). This stage serves to assess the feasibility of multimedia that has been made. The results of multimedia testing by media experts are described in **Table 3**.

Table 3. Media and material validation.

Media validation		
Average media validation by experts	**Average media validation by teachers**	**Average score**
79%	85%	82%
Material validation		
Average material validation by experts	**Average material validation bt teachers**	**Average score**
88,70%	92,79%	90,74%

From the table, the value obtained from the average results of media validation by experts is 79%, while the average validation by teachers is 85%, the average score of media validation is 82%. The average material validation by experts was 88.70%, while the average material validation by teachers was 92.79%, so the average score of material validation was 90.74%. Based on this research categorized as "Very Good", the interactive multimedia that has been made is considered feasible to be tested on a predetermined sample.

3.4. Results of Improving Cognitive Understanding

There is a significant increase between student scores before using this Augmented reality interactive multimedia and student scores increase after learning using interactive multimedia. This is known from the increase in pretest and posttest scores. The average value obtained from the pretest and posttest results based on the calculation results is 50.45% for the pretest and 84.18% for the posttest. The average of both pretest and posttest results can be depicted in a bar chart in **Figure 20**.

Based on the diagram above, it states that the average student score has increased. From this comparison there is a difference of 33.73%. To determine the cognitive improvement of students there is a learning media using interactive multimedia based on Augmented reality n-gain analysis. The results of the n-gain analysis can be seen in **Table 4**.
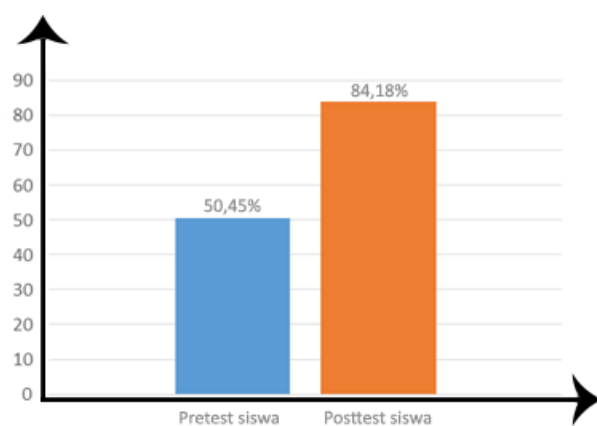
Figure 20. Average of pretest and posttest results.

Table 4. Average gain score by group.

x̄ pretest	x̄ posttest	x̄ n-gain	Effectiveness
49	81.75	0.65	Medium

Based on **Table 4** the average student n-gain is 0.697 which is interpreted in the "medium" effectiveness criteria, which means that the learning media based on interactive multimedia Augmented reality is effective enough to be used to improve students' cognitive.

3.5. Assessment Results and Student Feedback

The responses given by students to interactive multimedia based on Augmented reality interactive multimedia in using this interactive multimedia are also quite high, this can be proven from the results of the student response instrument regarding learning using multimedia with an average value of 85.75% categorized as "Very good" which means that students are enthusiastic about learning using interactive multimedia applications based on Augmented reality.

4. CONCLUSION

Augmented reality-based interactive multimedia is designed and developed through the Comprehensive Life Cycle (SHM) whose stages are the analysis stage, design stage, development stage, implementation stage, and assessment stage. Interactive multimedia has been assessed by media experts, material experts and teachers, obtained a media score of 82% and 90.74% material, both of which are interpreted as "very good" and feasible to use.

Students' cognitive outcomes increased after the application of Augmented reality-based interactive multimedia learning on network topology material. This is evidenced by the average n-gain value of 0.697 which is interpreted into the "medium" effectiveness level. The highest increase in the n-gain value occurred in the upper group which obtained an n-gain of 0.889286. The increase also occurred in the middle group with an average n-gain value of 0.67429. And the lower group got an average n-gain value of 0.557265.

Student responses after Augmented reality-based interactive multimedia learning are quite good with an average value of 85.75%. Which is categorized as "very good". This is in line with the average cognitive results obtained by using interactive multimedia.

Based on the research conducted, there are recommendations to be conveyed. The suggestions are as follows:
(i) It is better to develop more interactive learning multimedia with various platforms. Aiming so that not only users of one platform use interactive multimedia.

(ii) In developing multimedia, it is necessary to pay attention to the balance between learning and content.

(iii) The learning multimedia designed and built has not fully reached the application stage. Researchers are only limited to conducting trials. For future researchers, learning multimedia should be applied in teaching and learning activities in the classroom.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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