



Development of augmented reality-based learning media to improve student learning outcomes in the subject of electric motor installation at SMK Negeri 2 Yogyakarta

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ABSTRACT (10 PT)

In the Electric Motor Installation material there are limitations in the form of requiring the physical form of components to introduce components directly. The development of learning media developed is Electric Motor Installation Learning Media for augmented reality-based learning to overcome limitations and provide alternative learning resources that so far teachers have used conventional learning media. The developed learning media includes 3-dimensional electric motor installation components displayed with augmented reality technology. The method in this study is research and development with the ADDIE model. Preliminary studies were conducted by analyzing the needs of basic competencies using questionnaires and interviews. Testing the effectiveness of learning media and knowing learning outcomes is carried out using the post-test and pre-test methods which produce valid values for 30 items above the value of 0.30 and reliable above 0.6. The results of the effectiveness test obtained a percentage of 56-75% so that this learning media was declared effective. Student responses to the feasibility of learning media showed that 20 students stated that it was very feasible and 10 students stated that it was feasible so that they concluded that learning media was feasible for use in learning Electric Motor Installation.

Keywords: Instructional Media, Augmented Reality, Electric Motor Cycle Instalation



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INTRODUCTION

In this age of globalization, the accessibility of science and technology is increasing rapidly, particularly in the field of education. Education is the process of changing the attitudes and behaviors of individuals and groups in the pattern of efforts to mature humans through training, development, learning, and teaching. In order to keep up with the growth of science and technology, the government determines programs with increased quality and excellence by implementing the Merdeka Learning Curriculum Standard, where as a reference for implementing education in Indonesia, some schools still use the 2013 Curriculum (K13), which states the importance of inviting students to develop learning skills, encourage collaboration and communication, and increase creative abilities to think freely but still follow the rules at school.

Teachers have flexibility in learning in the 2013 curriculum (K13), but they still concentrate on learning to meet national education orientation objectives and follow the curriculum. Vocational schools focus on developing students' job skills. Student-teacher-resource interaction is learning. Learning tactics, methods, and media are crucial. Excellent people come from good learning. To hold students' attention, a classroom must be beautiful, fascinating, and enjoyable, offering dynamic, thrilling, and memorable experiences and chances for active engagement. Information and communication technology make education ubiquitous and accessible in the information age. New technology and improved pedagogical tools are creating unique digital learning environments where students may collaborate and participate. Students become more interested in studying and actively engage.

The growth of science and information technology plays an important role in preparing students for the progress of the nation. One effort is to improve the quality of learning. The educational process plays a very important role in creating qualified and intelligent human resources. According (De Pauw et al. 2015) states that the main goal of smart education is to harness the potential of smart things and smart technology to create an environment where training is consistent with the needs and

characteristics of the new digital learner and modern society. Smart technology is changing the learning and teaching processes. They support the development of knowledge, skills, and competencies to improve outcomes and evaluate alternatives in decision-making. By using smart technology, students can learn how to make decisions based on available information and knowledge rather than remembering predetermined solutions. To make lessons more interesting, one of the uses of scientific and technological developments is to use learning media. According (Asyhar 2012) describes learning media as having a vital role: a means or tool that functions as an intermediary or channel in a communication process between communicators and communicants. Various forms and types of learning media can be a source of knowledge for students (Amirullah and Hardinata 2017).

The use of a learning medium can make learning more attractive and stimulating so that it is more interactive, topics are easily understood, learning methods are more diverse, students become more agile, and the learning process can be carried out anytime and anywhere (Anwaringsih and Ernawati 2013). The use of learning media aims for a teaching and learning process that can generate new desires and interests, motivation, stimulation of learning activities, and even psychological influences (Firdawati, Maison, and Nazarudin 2021). The more interesting the media used and supported by the delivery of material by communicative teachers, the more interested students will be in following the lessons in class. In addition, media can make learning more fun, not boring, and increase student interest, as stated by Artic (2019). In addition, the use of interesting learning media will be able to increase students' understanding of the subject matter. The point of learning media is to capture, process, and reassemble visual and verbal information. As a tool in teaching, the media is expected to provide concrete experiences, motivation to learn, and enhance the absorption of students. These media are in the form of graphics, films, slides, photos, and animations, as well as media obtained online, which is commonly referred to as learning multimedia (Sadiman, Rahardjo, and Haryono 2014). This learning medium requires an explanation of the subjects of electric motor installation that is good and right. One of the subjects considered difficult for students

According to observations and early investigations at SMK Negeri 2, Yogyakarta, pupils had trouble distinguishing sections of the picture and the fundamental components of the electric motor installation. This is because home schooled kids cannot physically examine electric motor components. Traditional media also makes pupils less engaged and enthusiastic in studying. Indirectly, this will impair learning. Research studies show that the use of multimedia learning can increase the effectiveness and attractiveness of teaching and learning for students (Kesim and Ozarslan 2012). The results of other studies show that the use of learning multimedia can improve the quality of teaching and learning so that it can increase student competence (Nincarean et al. 2013). The learning process using information and communication technology makes students more competitive, broad-minded, and independent, one of which is by using augmented reality learning. Augmented reality technology is a technology that incorporates 3D virtual objects into the real environment of 3D objects in real time (Azuma 1997). Augmented reality (AR) shows virtual information or objects into the real world, which enables a reality where virtual objects appear to coexist in the same space as the real world. Unlike virtual reality, which completely replaces reality, augmented reality (AR) simply adds to or complements reality (Azuma, 1997b). Although AR and VR technologies have been around for some time, they are only recently being utilized in educational contexts (Bujak et al. 2013).

AR fits perfectly with the idea of "learning everywhere," where everyone is learning all the time, wherever they are, when they need it. One of the advantages of using AR media is using a smartphone device. These smartphones have a very low cost of use compared to other permanent technologies, such as personal computers (PCs). Smartphone features continue to improve every day, while prices are becoming increasingly affordable (Craig and Craig 2013). Smartphones have operating systems (OS), namely system software, whose job is to manage hardware and carry out basic operations on devices, for example, running application programs. The basic function of the operating system is to run and manage the hardware and also to perform basic operations on the system. There are several smartphone operating systems (OS) that are used in the market, including Blackberry, iOS, Symbian, Windows Phone, and Android. A research report from Stat Counter describes OS usage by country (region) from April 2020 to April 2021 as follows: Android 91.7%, iOS 8.31%, Samsung 0.38%, Windows Phone 0.35%, unknown 0.32%, and Nokia 0.31%. Based on this data, it shows that the use of smartphones with Android OS is the highest in Indonesia (StatCounter, 2021). The use of Android as a learning aid is expected to improve students' cognitive learning outcomes and can also build

students' self-confidence that they are able to understand the material being taught. Students can learn independently, not limited by space or time, and add to the learning experience.

According (Rambousek et al. 2014) found that combining AR to audio-visual instruction improves students' cognitive capacities. According to (Saputro and Saputra 2015) AR as an Android-based learning medium gives students various learning experiences, boosts self-confidence, and improves learning results. Without an operating system, cellphones cannot execute applications. Thus, cellphones need many implementation programs to operate apps. By teaching Blender and Unity, this AR media curriculum may help build information and communication technologies. The Netherlands-based Blender Foundation manages the animation and 3D modeling tool Blender. Blender was released in August 1994 as an integrated tool for creating 2D and 3D content. This free software is open-source. Blender can generate 3D visualizations, item designs, animations, and games using its 3D Engine game. NaN increased Blender.

The Unity program is a game development application that includes interactive 2D and 3D content development, rendering, a physics engine, a scripting interface for creating interactive programs, exporter content for platforms (desktop, web, mobile), and various community support to increase knowledge (Winkler 2013). The Unity program is multiplatform, which means it can be used on a variety of devices, including Android, iOS, Windows Phone, PC, web applications via plug-ins, and game consoles. In this era of modern technology, various uses of electronic media, such as AR in learning media, were created to improve, develop, and innovate quality in education (Ghosh 2013). Even with the current advances in AR technology, sight and hearing can not only perceive the reality of the virtual world but also other sense organs. Furthermore, the use of AR technology as a learning medium has an influence on students, namely the feeling of presence, closeness, and understanding of learning material. By using AR, learning can be done anywhere through collaborative and situated learning (Wu et al. 2013). The applied technology is interactive and more interesting because the information conveyed is more interactive with the students who use it. AR-based learning multimedia that is simple to use and accessible from anywhere encourages students to learn independently.

RESEARCH METHODS

This study used the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, and Evaluations) procedure. The data analysis technique uses a quantitative descriptive analysis technique to describe the validity, practicality, and effectiveness of augmented reality-based learning media. According to Sugiyono (2018), the quantitative method is used because research data is in the form of numbers and analysis uses statistics. This methodological model was chosen because the researcher would develop a learning medium. The ADDIE methodology model is considered appropriate for developing a product in learning (Sweller 2021). The data taken from the research instrument is in the form of quantitative data, namely questionnaire scores, and qualitative data in the form of interviews from several product assessment questionnaires by media experts, material experts, and student responses and observation guidelines.

RESULTS AND DISCUSSION

Initial Product Development Results

Needs Analysis

Functional, non-functional, SDK, and basic application requirements are stated at this level. A literature research and school interviews determine needs analysis. The preliminary research included interviewing instructors who teach electric motor installation material and giving students questions to help design learning media that fits their needs. 30 students completed the questionnaire. The appendix shows student questionnaire responses. In response to question 1, most students questioned the instructor if they were having trouble studying, while the remainder searched the internet and other media for solutions. Students actively solve learning issues. Non-conductive classroom environments lead pupils to lose concentration and not grasp teachings. Some complained about tiredness, others about the teacher's pace. Even so, 27 students said the instructor explained and transmitted the subject well enough, and the teacher would question which portions the students didn't understand and re-explain until they did. Additionally, although PowerPoint is used to teach, it is followed by practical tasks, which most students found sufficient.

However, 5 pupils reported being bored in class, with some blaming the equipment. Smartphones are the most widely accessible learning tool for pupils. Most kids think smartphones help learning since they're permitted in class. PowerPoint is still utilized to convey topics, and pupils believe they understand enough. AR-based learning media may be created utilizing engaging learning media. Most kids don't know about AR, therefore it's a chance to educate them. According to discussions with various instructors, AR-based media has not been employed in teaching materials. The instructor instructs the student to utilize school-provided trainers or a simulation application to model an electric motorcycle if 3-dimensional imagery is needed for comprehension. Distance learning material must also show electric motor components. Since all students have Android smartphones, learning material should be transformed into Android apps. Android apps promote individual study.

In addition to completing the needs analysis, a literature study was carried out. The following are the results of the literature study:

Functional Requirements

The functional requirements of the Electric Motor Component Installation application are described based on their learning needs for the electric motor component installation material, so that presentation of the material is required in the form of AR, text, and images. The functional requirements are to be able to display 3D objects in AR form, to be able to display application descriptions, to be used to do quizzes, to be able to see the score of the results of doing the quiz, to be able to see the wrong and correct answers after taking the quiz, and to be able to see the answer key after working on the quiz.

Non-Functional Needs

Non-functional requirements are requirements needed by the system so that it can run. Following below are the non-functional requirements of the application, namely that it can be downloaded, that it can be accessed via various kinds of Android smartphones, that it has an interface that is adapted to the size and layout of the Android smartphone, and that it can access the camera.

SDK specifications

A literature review on AR learning media and the AR SDK was used to determine a suitable SDK for Unity-based AR learning media development. ARToolkit, Augment, Aurasma, BlippAR, CraftAR, EasyAR, Kudan, LayAR, PixLive, Vuforia, and Wikitude are popular education SDKs (Herpich et al., 2017a). Vuforia, along with Metaio, is the most extensively used AR development framework. Because it was designed as an application, it supports the most platform extensions (Herpich et al., 2017b). Vuforia, Metaio, Wikitude, ARToolkit, D'Fusion, and ARMedia were compared for licensing (Amin & Govilkar, 2015a):

Table 1 Comparison of the use of the AR SDK in terms of licenses

AR SDK		Vuforia	Metaio	Wikitude	ARToolkit	D'Fusion	ARMedia
<i>Type</i>							
<i>License</i>	<i>Open Source</i>	x	x	x	✓	x	x
	<i>Free</i>	✓	✓	✓	✓	✓	✓
	<i>Commercial</i>	✓	✓	✓	✓	✓	✓

ARToolkit is a free, open-source, and commercial SDK. Since Unity allows free licensing, it is the only open source SDK that does not need characteristics while building apps. It must have an automated Unity and Vuforia watermark on the camera screen during development. This learning medium is still under development, but the SDK, which allows free licensing, will not be an issue. Vuforia, Metaio, Wikitude, ARToolkit, D'Fusion, and ARMedia can display 2D and 3D content according to standard. Amin and Govilkar's table below lists each SDK's 2D and 3D capabilities (2015).

Table 2 Comparison of the use of the AR SDK in terms of overlaying

AR SDK		Vuforia	Metaio	Wikitude	ARToolkit	D'Fusion	ARMedia
<i>Type</i>							
<i>Overlaying Capability</i>	<i>2D Content</i>	✓	✓	✓	✓	✓	✓
	<i>3D Content</i>	✓	✓	✓	✓	✓	✓

AR SDK Type	Vuforia	Metaio	Wikitude	ARToolKit	D'Fusion	ARMedia
Others	3D animation can be overlaid on screen	Billboard can be overlaid	Sprite animations, 3D transformations and HTML contents	Support high level graphic content and animations.	3D animation can be overlaid on screen	Interactive 3D animation through SketchUp

Vuforia and ARToolKit are SDKs with several benefits over others. Only Vuforia's developer.vuforia.com/ community can help with development issues. ARToolkit lacks a community. Vuforia is also frequently developed and updated, unlike ARToolkit, which needs volunteer contributions. Vuforia and Unity were utilized to develop AR apps. Developing electric motor component installation apps requires the following tools:

Table 3 Required Development Tools

Tool Type	Tool's name
AR SDK	Vuforia
Mobile App SDK	Unity

Minimum Application Requirements

Smartphones run the Electric Motor Component Installation Application. The Electric Motor Component Installation Application requires WebRTC. WebRTC is built into all smartphones. Minimum smartphone requirements apply. Since Samsung is the most popular smartphone till 2022, the minimum requirements are Android 6.0 (Marshmallow) and Samsung's specs. To show 3D objects, the Electric Motor Component Installation Application requires numerous more minimal criteria. The minimal requirements are 15 FPS camera speed, 1.5 Ghz Dual Core CPU, 1.5 GB RAM (up to 2 GB), HD screen resolution, 500 MB free storage, and Vulcan Rendering API (to build 3D graphical visualizations).

Learning Media Design

At this stage, the application design process is carried out. In the design stage, use case diagrams, flowcharts, and interface designs are made. The design is carried out with the aim of planning so that the application development process has a clear picture and so that the application is made in accordance with the initial research objectives and user needs. Here are the steps:

a. Use case diagram

Use case diagrams to explain the relationship between actors and functional functions. The following describes this relationship, which consists of four main functional functions or features.

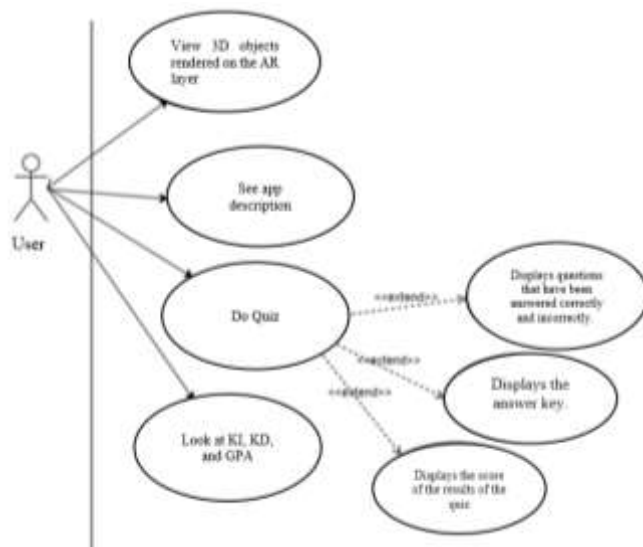


Figure 1 Use Case Diagram of Learning Media for Installing Electric Motor Components

b. System Workflow Design

After a splash screen, the main page displays. The main page allows manual input by pushing buttons. The homepage has five buttons: KI KD, material, evaluation, description, and quit. The flowchart of the produced learning medium is below. 4.3 shows a flowchart. In figure 4.3, the flowchart begins with the start sign, indicating the start of the Electric Motor Installation Application, followed by a box symbol, indicating application activity. It produces photos, text, movies, animations, and AR objects.

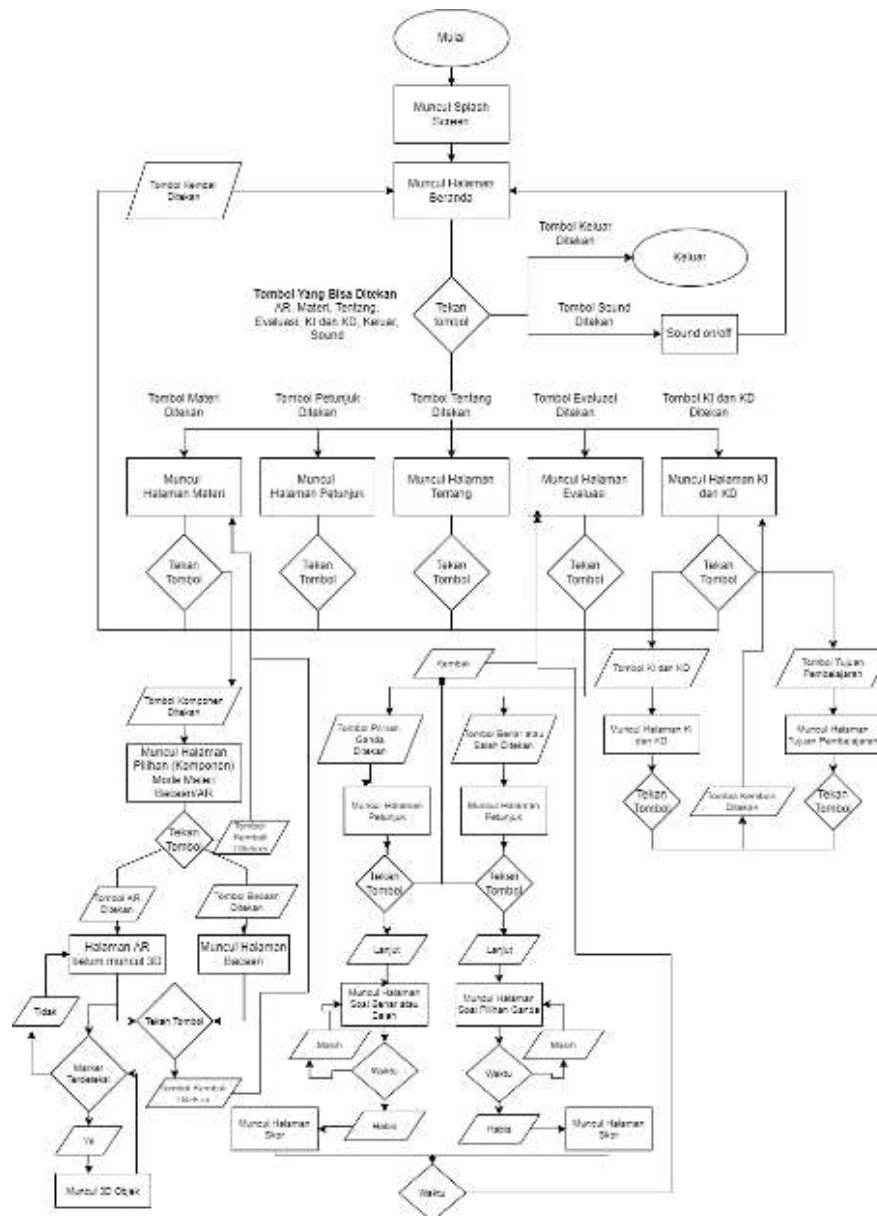


Figure 2 Workflow of the Electric Motor Installation Learning Media System

c. Interface and storyboard design

1) Storyboard *Splash Screen*



Figure 3 Storyboard *Splash Screen*

The splash screen is the media section that starts first. The identity of the media "Introduction to Electric Motor Components" is displayed.

2) Home Page Storyboards



Figure 4 Home Page Storyboards

The home page of the learning media has buttons, including the sound button to activate background entry, the "Material" button to go to the material page, the KI and KD buttons to display information about KI, KD, and Competency Achievement Indicators, the about button to display information about the learning media, the evaluation button to display the evaluation page, and the exit button to exit.

3) About Page Storyboards



Figure 5 About Page Storyboards

A page that displays information about the application briefly

4) Storyboard Halaman KI dan KD



Figure 6 Storyboard Halaman KI dan KD

Pages that display information on KI, KD, and indicators of competency achievement

5) Material Storyboards



Figure 7 Material Storyboards

Pages that display materials for electric motor components. On the first page, there are 5 material buttons, namely switches, buttons, relays, contactors, and circuit breakers.



Figure 8 Page Showing The Selected Material Component

After the student selects one of the materials, it will proceed to a page that displays the selected component material. On the selected material page, there is material text, a back button, and a sound button.

6) Storyboard AR



Figure 9 Storyboard AR

A page that displays AR features for understanding how electric motor components work, starting from the appearance of available AR material buttons based on groupings, namely switches, buttons, relays, contactors, and circuit breakers



Figure 10 To The AR Page Containing The Component Mechanism Panel

Then, after students select one of the buttons or materials, they will be directed to the AR page, which contains a panel of the working mechanism of the component, an AR panel that displays an animation of the circuit mechanism of how the component works, and 3D objects of the component.

7) Evaluation Storyboards



Figure 11 Evaluation Storyboards

Displays an evaluation page that begins with a selection of question types and then asks students to select one type of question, such as multiple choice or true and false.

Marker Design

Markers are designed with a contrast between the marker background and the marker object to be easily captured by the camera. The goal is to make it easier for Vuforia to read for marker recognition processing. In addition, markers made based on the conditions provided by Vuforia need to comply with the following conditions images must have a high level of detail, or at least have a large number of pixels in one image, images must have a feature or a unique pattern compared to images in general, and use an image that does not have a dominant color in the object image.

Learning Media Development

Interface / User Interface (UI) Development

The following is the Electric Motor Component Installation Application:

1) Home Page

There are 5 main buttons on the home page, namely the KI and KD buttons that lead to the KI and KD pages, the Material button that leads to the material selection page, the Description button that leads to a description page about the application, the Evaluation button that leads to the evaluation question work page, and the Exit button to exit the application.



Figure 12 Results of the Home Page UI Design Implementation

2) Material Page

The user will choose display content on this page. Switches, circuit breakers, lights, relays, contactors, and buttons are the six essential materials for electric motor installation. These buttons open material mode selection pages. The content mode page lets users select between reading and AR modes. If reading mode is chosen, content will appear in text alone, but if AR mode is selected, material will appear in 3-dimensional AR form with a brief sentence explaining how the components are shown.



Figure 13 Results of the Material Page UI Design Implementation at the Beginning

Below, you can see a screenshot of the material page in reading mode, so that the material is presented in text form.



Figure 14 Results of the Implementation of Material Page UI Design in Material Reading Materials

The screenshot below shows a material website in AR mode with a camera capture collecting photographs and a material user interface layer above. The text material portion explains the working process, the button section runs 3D AR object animations, and the section shows 3D AR objects.



Figure 15 Results of the Implementation of the Material Page UI Design in the AR Section
3) Pages of KI, KD, and Achievement Indicators

KI and KD pages are pages that display information on core competencies, basic competencies, achievement indicators, and competencies that underlie the presentation of electric motor installation component material. Each button, when pressed, will lead to a page according to its respective purpose.



Figure 16 Results of Material Page UI Design Implementation

The screenshot below displays information about the competency achievement indicators to be achieved.



Figure 17 Results of Material Page UI Design Implementation

The screenshot below shows the basic competency page you want to achieve.



Figure 18 Results of Material Page UI Design Implementation

The screenshot below contains information about the core competencies of electric motor installation component materials.



Figure 19 Results of UI Design Implementation of KI and KD Pages

While the screenshot below is the result of development for the competency achievement indicator page, here is a screenshot.



Figure 20 GPA Results of Implementation of UI Design GPA Page

4) Description page

The description page contains descriptive information regarding the application of learning media for electric motor installation components.



Figure 21 Implementation of the Description Page UI Design

5) Evaluation Page

The evaluation page is a page for working on evaluation questions, which can be of two types: multiple-choice questions and true-false questions. At the beginning of the evaluation page, a choice of question types will appear; select one to access the question. Then there is a time slot in the upper right corner for working on the questions.



Figure 22 Results of Material Page UI Design Implementation

After selecting one of the types of questions, you will be directed to the instructions page. The instructions page contains information on how to work on the questions and how to calculate the final score for questions answered correctly. To start working on the problem, you need to press the start button.



Figure 23 Results of Material Page UI Design Implementation

Then a question work page will appear that contains the questions worked and answer choices, as well as the continue button and the back button to navigate to the page before and after

the question worked. The image below is a multiple-choice question. There are five possible answers.



Figure 24 Results of Material Page UI Design Implementation

While the types of right and wrong choice questions are listed below. Users are asked to choose whether the statement is true or false. There are some questions that contain pictures and some that do not.



Figure 25 Results of the Implementation of the Evaluation Page UI Design

6) Guidance Material Page

The instructions page contains information regarding the instructions for use. To be able to open this page, it is enough to press the question mark button, which is located next to the sound button in the upper right corner of the screen.



Figure 26 Results of the Implementation of the Instructions UI Design

Product Trial Results

The product was tested by experts, namely two media experts and two material experts; each of the four experts stated that the application of electric motor installation learning media was feasible with revisions in accordance with the suggestions given by experts. Below will be described the parts that need to be improved in each aspect of the material and media.

Test Results by Media Experts

In the media section, there are several sub-aspects that are assessed, namely the display sub-aspect, the media sub-aspect, and the technical sub-aspect. For testing by the first and second media experts, produce the following:

Display Aspect

Media specialists, who are first, give high scores to the page's appropriateness with the title, the program's presentation, the menu's location in each program, and the content's color composition. While the rest, including text clarity, language clarity, content attractiveness, and display design, are considered good, the second media expert gave good ratings for all items, so the seven items on the display aspect that the first and second media experts evaluated on average produced a good assessment.

Media Aspect

All items in this aspect were assessed very well by the first media expert, namely the clarity of images and colors, the clarity of audio, and the clarity of AR-based 3D animation. Meanwhile, the second media expert gave good ratings for image and color clarity, audio clarity, and video clarity. As

for the clarity of 3D animation, it is considered lacking. So in this part of the media aspect, what needs to be considered for improvement is the clarity part of AR-based 3D animation.

Technical Aspect

The first media expert evaluated virtually all technical features well, including the simplicity of utilizing program applications, learning application workflows, navigation button correctness, program menu choice ease, and material freedom. The other four items—suitability in learning navigation, clarity of instructions, convenience of setting up and quitting the program application, and speed in accessing the software were excellent. The second media expert offered excellent ratings for all categories except software application ease of use, which was not good. The application program's usability requires improvement. Even though the two experts evaluated most items as excellent, each included correction comments. Electric motor installation learning media notes require correction: an explanation on the AR push button about NO- The NC is wrong, there are no full circuits and photos in the AR relay part, mistakes are still discovered, the language is inconsistent, there are some mixed English and Indonesian that might create misunderstanding, and it cannot displace.

Test Results by Material Experts

The results of the testing by the two material experts produce an assessment of each aspect as follows:

Material Aspect

In this aspect, there are eight items that are validated by the first material expert's very good assessment of the similarity of the material with curriculum standards, basic or core competencies, and learning goals, the clarity of the sentences used, and the suitability of discussing the material. Then the good assessment for the remaining items is the accuracy of the material, the depth of the material, the completeness of the material, the suitability of the content of the images and animations for the material, and the accuracy of evaluating the material for the quiz questions and tests. The second expert, on the other hand, gave a very good assessment of three items and a good assessment of five validation items. So it can be concluded that the material aspect is considered quite good.

Learning Aspects

11 items are validated for learning, and the first subject matter expert gives a very good assessment for 6 validation points: understanding program titles, competencies and objectives, study instructions, compatibility of AR with material, ease of understanding material by interpreting AR, and media AR attractiveness. Other items were favorably appraised, including learning exchanges, presenting strategies, student feedback, quizzes, and assessment compatibility with learning goals. The second material expert had a similar percentage of excellent and very good judgments as the first. Five validation items are very excellent and six are good. This component is often well-rated, therefore learning is beneficial.

Both of these documents provide notes to correct in the electric motor installation learning media, notably in the pre-test and post-test assessment questions: In questions 1 and 3, there are three correct answers; question 3 has a meaning that is not clear in the sentence "change to initial conditions"; in option e in question number 6, "the contactor carries current for the neutral wire" has a meaning that is not quite right; in question 7, the pictures S1, S2, S3, and S4 are not clear; in question 16, the writing "which is said to be control" has an incorrect meaning; and in question 19, the pictures S1, S2, The learning media area needs better visuals and animations.

Product Revision

Product revisions were made based on the test results from two media experts and two material experts. The following is a discussion of the results of the revision of the electric motor installation learning media:

Improvements in the media aspects

Improvements to the media aspect are based on the notes of the two media experts:

- a. No exit confirmation when the exit button is pressed.

Before the repair was carried out, when the exit button was pressed, what happened was that the application immediately exited. To anticipate the occurrence of the user accidentally pressing

the exit button, it is necessary to add an exit confirmation page when the exit button is pressed. So the user will leave the application consciously and intentionally. On the exit confirmation page, there are 2 buttons, namely the "Cancel Exit" button and the "Yes Exit" button. To exit, you need to press the "Yes, Exit" button again.



Figure 27 Revision Result for Exit Confirmation Page

b. AR Thermal Overload Relay (TOR) Not Displayed

AR is not displayed because there is a mismatch between the animation codes so that the TOR animation only displays text, and the 3-dimensional objects from TOR components are far beyond the reach of the screen. So the coordinates for the appearance of 3-dimensional objects are adjusted to be right above the text. The following is the result of the repair of the AR TOR not being displayed.

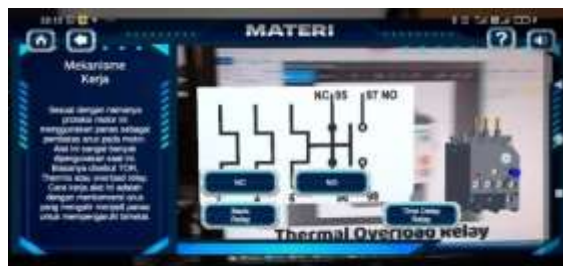


Figure 28 Revised Results for Thermal Overload Relay Pages

c. There is no information on the number of questions in the Evaluation Section

The assessment guide page corrects multiple choice and true/false questions by supplying question counts. The number of questions is stated at the beginning of the text so the user knows while reading the instructions.



Figure 29 Revised Results for Multiple Choice Type Evaluation Pages



Figure 30 Revised Result for True and False Type Evaluation Feature Instructions Page

- d. There are typos and inconsistent use of language.

In this section, the typo was found on the material selection page, which originally used button writing but was replaced with button writing so that it was uniform with the use of language on other pages. The following is the result of the repair.



Figure 31 Results of Revision of the Material Selection Page by Correcting Writing Errors on the Menu

- e. Improvements to the AR Relay

Initially, the AR relay did not display the circuit and animation of the relay, so the fix is to display the circuit and animation of the relay circuit. Below is the result of the repair. In the screenshot below, the relay circuit is successfully displayed when it is operated, which consists of the com branch that is connected to NO and disconnected from NC. When the NC button is pressed, the branch will move to connect to NC.



Figure 32 Revised Results for AR Relay Basic Pages

- f. Improved Image And Animation Quality

This is accomplished by increasing the maximum buffer code that Vuforia can execute in order to render more detailed images. The difference is not visible compared to before because it can only be seen at very low resolution.

- g. Improvements to Push-Button AR

What is wrong with the AR press button is the NO-NC inscription, which is displayed upside down, and the CN-ON, which is located in the series animation. so that it is corrected so that the correct writing is displayed, namely NO-NC. Below is the result of the AR pushbutton fix.



Figure 33 Revised Results for AR Push Button Pages

Material Aspect Enhancement

For improvements in this aspect of the material, focus more on improving pre-test and post-test evaluation tools. The following are the improvements based on the notes provided by the two material experts:

Questions 1 and 3 have 3 correct answers

For question number 1, the answer choices are: (a) stator; (b) rotors; (c) bearings; (d) main shafts; (e) transistors, with the answer key e, namely transistors; for question number 3, with the question sentence, "A forward and reverse electromechanical control system used to run a machine that uses an induction motor as its drive is called...", with the answer key e, "star delta controller."

Question number 3 has an unclear meaning in the sentence "change to initial conditions".

In this section, improvements have been made in the form of changing the question sentence as explained above.

In option e in question number 6, "the contactor carries current for the neutral wire" has an incorrect meaning.

In this section, improvements have been made by changing the question to "If the contactor coil is not connected to an electric current, then whether the contact is open or not connected...", with the answer choices (a) normally closed, (b) push button, (c) normally open, (d) TORs, and (e) MCB. Answer key c is normally open.

In question number 7, pictures S1, S2, S3, and S4 are not clear enough to see.

In question number 7, the question is changed to "Look at the picture below." "Components marked with the letter C have a working principle" with the following figure :

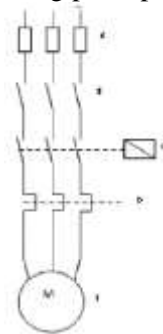


Figure 34 Problem Results of the Revision for Question Number 7

With the following answer choices:

- Excessive heat caused by current flowing through the bimetallic heating elements will cause one of the metals in the bimetallic to buckle and move the mechanical contacts of the circuit breaker to open.
- If there is no current, the contact will remain stationary. But if current is flowing after closing the switch, the NC contact will be open while the NO contact will be closed.
- When the component is not working, the contact position closes, and when the component is working, the contact opens.
- When the component is not working, the position of the contact is open, and when the component is working, the contact closes.
- The component will work if the electric motor gets an AC voltage, rotates the mechanical gear, and pulls and closes the contact mechanically within a certain period of time.

With the answer key: B

In question number 16 the writing "what is said to be control" has an incorrect meaning.

In question number 16, the question is changed as follows: "The magnetic contactor will work if..." with the following answer choices: (a) The main contact gets voltage; (b) No auxiliary contacts get voltage; (c) Contact Auxiliary to get voltage; (d) Push-Button Switch gains voltage; (e) The contactor coil gets voltage. Answer key: D.

In question number 19, the sentence "control components that function to create more load on the motor" is not correct.

In question number 19, the question was changed to "The function of the jog button on the electric motor control system works temporarily to operate..." with the answer choices (a) the standby indicator light; (b) work sign lights; (c) the electric motor works temporarily; (d) electric motors work continuously; (e) work overload; and the answer key: C.

Final Product Review

Products that have been validated by experts are then repaired according to the suggestions of the validators, and direct testing can be carried out in the field to determine feasibility from the user's point of view and effectiveness. The product was tested directly on 30 students at the school. Following the collection of data on student responses to the pre-test and post-test, as well as the feasibility of

learning media, Then these data need to be reviewed for the validity and reliability of their values. The following is the language for analyzing the data using SPSS:

Pre-test Data Analysis

The data to be analyzed needs to be carried out several steps before the data is ready to be used in the analysis, namely:

- a. Data checking is carried out first, with the aim of ensuring the data is clean. If the data is not clean, it is necessary to do cleaning or data cleaning. As seen in the appendix on page 130, the type of data that is owned by the table is still in the form of letters or characters. In order to be able to count, these letters can be converted into values that represent options a, b, c, d, and e, which are commonly represented by the numbers 1–5.
- b. Data cleaning is done to clean data from sources that cannot be processed by SPSS. In this case, there are several steps so that the data can be used in SPSS, namely :
 - 1) Data needs to be converted into numerical or numeric form because, if it is in alphabetical or character form, SPSS will not be able to process it for the purposes of checking validity and reliability.
 - 2) For blank data, it is necessary to fill in relevant data; for example, if there are students who do not answer the questions, then the data is empty. So that there is a value that can be processed, it is necessary to give an average value.
 - 3) Eliminate characters that are not allowed in SPSS, such as ;, :, *, or other symbols.
- c. After the data is confirmed to be clean (see page 131), validity is checked using SPSS. Below is the pre-test question data that is ready to be used for validity.
- d. The results of the validity test of the items on the pre-test

The validity test in this study was carried out using the two-way bilinear correlation method. with a DF value of 28 and a significance level of 1%. Then the value of r table obtained for 30 items produces a valid range with a range of 0.330-0.700. so that each item below the r table value will be considered invalid. For pre-test data, all items have a value above 0.330 (as can be seen in the attachment), so it can be said that all question items in the pre-test are declared valid.

e. Pre-test reliability test results

The following is a table of reliability test results using SPSS. It can be seen that Cronbach's alpha has a value above 0.6, namely 0.608, so the items are declared reliable. Even so, it is of particular note because this value is very close to the threshold of reliability. so that the level of reliability can be doubted.

Table 4. Reliability Test Results for Pre-test

Reliability Statistics	
Cronbach's Alpha	N of Items
.608	30

For Cronchbach's alpha, the value is 0.608, so further examination is needed as an optional option, even though this value is above the threshold.

Post-test Data Analysis

The data to be analyzed needs to be carried out in several steps before it is ready to be used in the analysis, namely:

- a. Data checking is carried out first, with the aim of ensuring the data is clean. If the data is not clean, it is necessary to do data cleaning (see page 132). The data type owned by the table is still in the form of alphabets or characters. In order to be able to count, these letters can be converted into values that represent options a, b, c, d, and e, which are commonly represented by the numbers 1–5.
- b. Data cleaning is done to clean data from sources that cannot be processed by SPSS. In this case, there are several steps so that the data can be used in SPSS, namely :
 - 1) Data needs to be converted into numerical or numeric form because, if it is in alphabetical or character form, SPSS will not be able to process it for the purposes of checking validity and reliability.

- 2) For blank data, it is necessary to fill in relevant data; for example, if there are students who do not answer the questions, then the data is empty. So that there is a value that can be processed, it is necessary to give an average value.
 - 3) Eliminate characters that are not allowed in SPSS, such as ;, :, *, or other symbols.
- c. After the data is confirmed to be clean (see page 133), validity is checked using SPSS. Below is the pre-test question data that is ready to be used for validity.
- d. Post-test validity test results

The results of the validity test on the post-test data were carried out using the biserial method, namely to determine the biserial correlation value. If the Pearson value is above the R table value, then the question item is declared valid. There are 30 items, each with a DF of 28, a significance value of 0.3, and an r table value ranging from 0.340-0.550. Based on the test results using SPSS (see attachment), all items have a value above the r-table, so they are declared valid.

- e. Post-test reliability test results

The following is a table of reliability test results using SPSS. It can be seen that Cronbach's alpha has a value above 0.6, namely 0.819, so the items are declared reliable. Even so, it is of particular note because this value is very close to the threshold of reliability. so that the level of reliability can be doubted.

Table 5. Reliability Test Results for Post-test Reliability Statistics

Cronbach's Alpha	N of Items
.819	30

Based on the results above, it can be seen that the Cronbach's alpha value is a reliability value. The higher the better, but the benchmark is said to be quite reliable if it is above 0.819.

Gain valuable results.

The gain value results are calculated using SPSS and are based on the assessment indicators below:

Table 6 Calculation Category N Gain with SPSS

No	Nilai Gain	Category
1	$g \geq 0.70$	Tall
2	$0.70 > g \geq 0.30$	Currently
3	$g < 0.30$	Low

So as many as 8 people are categorized as low-N gain, while the remaining 22 people are categorized as medium-N gain. See the table below.

Table 7 N-Gain Calculation Results with SPSS

N-Gain	Respondents	N-Gain	Respondents
15,43	R1	38,83	R16
50	R2	38,83	R17
47,57	R3	21,41	R18
50	R4	38,83	R19
50	R5	38,83	R20
22,33	R6	55,99	R21
35,37	R7	44,97	R22
21,41	R8	42,33	R23
47,57	R9	35,37	R24
31,37	R10	38,83	R25
26,6	R11	35,37	R26
44,97	R12	8,35	R27
21,41	R13	47,57	R28
50	R14	50	R30
42,31	R15	47,57	R30

As a result, with the presence of learning media for electric motor installation components, it can be concluded that students have a moderate understanding. while the rest is said with moderate understanding and a minimal percentage. To find out whether learning media are effective or not, you can use the table below as a benchmark for determining effectiveness.

Table 8 Categories of N-Gain Effectiveness Interpretation

Percentage (%)	Interpretation
< 40	Ineffective

40 – 55	Less effective
56 – 75	Effective enough
> 76	Effective

Sumber : Hake, R.R, 1999

According to previous data collection, 73% of students have moderate understanding, while 27% have low understanding. So it can be said that the percentage is 57–75%, so it can be said that the learning medium for installing electric motor components is interpreted as quite effective.

Data Analysis of the Feasibility of Learning Media by Students

Prior to data analysis to determine feasibility, it is necessary to examine the validity and reliability of the data collected from 30 respondents.

Table 9 Table of Reliability Data Feasibility Results of Learning Media by Students

Reliability Statistics	
Cronbach's Alpha	N of Items
,799	18

The Cronbach's alpha value above is 0.799, which above the CA requirement of 0.6. such that feasibility data is trustworthy for analysis. Meanwhile, the bisectonal correlation value may assess validity. by calculating pre- and post-test validity using the same procedure. All 18 items have bisectonal correlation values over 0.3061. (see attachment). Based on the score category range table below, learning media feasibility data may be obtained from valid and trustworthy validity and reliability findings.

Table 10 Table of Category Feasibility Score Range of Learning Media

Value	Score Range	Category
4	$x \geq 3.0$	Very worth it
3	$3.0 > x \geq 2.5$	Worthy
2	$2.5 > x \geq 2.0$	Not worth it
1	$x < 2.0$	Very unworthy

Table 11 Table of Obtaining Eligibility Scores for Each Student

Score	Respondents	Score	Respondents
3,43	R1	2,53	R16
3,43	R2	3,35	R17
3,38	R3	3,58	R18
3,37	R4	3,47	R19
3,35	R5	3,30	R20
3,92	R6	2,55	R21
3,36	R7	3,36	R22
3,88	R8	2,83	R23
3,30	R9	2,83	R24
3,30	R10	2,56	R25
3,34	R11	2,91	R26
3,45	R12	2,82	R27
2,76	R13	3,36	R28
2,52	R14	3,37	R30
2,56	R15	3,33	R30

Of the 30 students who were asked to fill out the questionnaire, as many as 20 students who filled it out produced scores in the "very decent" category. While the remaining 10 students who filled out the questionnaire produced a decent score, So by looking at only the feasible and very feasible options that appear, it can be said that the learning media developed according to the students are said to be feasible.

CONCLUSION

Based on the research and development, the product has become a learning media product based on AR electric motor installation, which has gone through the ADDIE phases. Start with the analysis stage, which involves data collecting for the design stage, then go on to the design stage, which involves developing learning medium so that product development may be successful. Programming the augmented reality system algorithm develops learning media. Two media and two material specialists validated the medium after development. Validation checks media feasibility before testing on students.

According to expert validation, the learning medium were workable but required improvement. Students use the restored product for three days before giving feedback. The pre-test biserial correlation validity was 0.330-0.700 for 30 items and 0.608, while the post-test validity was 0.340-0.550 for 30 items and 0.819. 73% of pupils comprehend moderately, whereas 27% understand poorly. Then input 56-75% to interpret electric motor component installation for the learning medium. The net gain value suggests that learning media enhance results. In addition, 20 students answered correctly for the learning media they use, indicating that the learning media for electric motor installation is practical.

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