DEVELOPMENT OF INTERACTIVE MULTIMEDIA FOR PHYSICS LEARNING ON ELECTROMAGNETIC INDUCTION MATERIAL TO IMPROVE CONCEPT MASTERY

Mintarsih
Study Program of Electrical Engineering
Bogor Technology Academy
Email: alyamientarsih@gmail.com

Arif Harbani
Faculty of Informatics and Computers, Study Program of Information Systems
Indonesian Binaniaga University
Email: a_harbani@gmail.com

ABSTRACT

The majority of students have not mastered the concepts of physics which is the background for this research to be carried out. The research aims to produce interactive multimedia for physics learning on electromagnetic induction material and analyze the effectiveness of this product in increasing concept mastery. The research method is Research and Development, followed by pre-experimental research. The development procedure was adapted from Sukmadinata model with three steps: preliminary study, product development, and product test. Data collection strategy using assessment sheets and pretest-posttest. The validation of interactive multimedia as shown by the research results is 95.15%, including the very good category. Classical learning completeness of 94% meets the criteria to be achieved in the research. The conclusion from these results is that interactive multimedia for physics learning on electromagnetic induction material is very good and effective for increasing concept mastery.

Keywords: *electromagnetic induction, interactive multimedia, physics learning, concept mastery*

1. INTRODUCTION

One of the biggest challenges in physics education at various educational institutions is the complexity of understanding abstract concepts. Abstract physics material is often difficult for lecturers to explain and for students to understand because these concepts cannot be directly observed [1]. Physics learning often encounters challenges, especially with abstract concepts that are difficult for both lecturers and students to visualize directly Concepts are schemas, mental models, and implicit or explicit theories regarding how knowledge is connected [2]. Students' ability to remember and understand the meaning of the lesson material presented and then apply the lesson material in concrete form is the meaning of concept mastery [3].

Analysis of students' pretest results on electromagnetic induction material, only 48% of students' classical scores were able to achieve the minimum score according to the set standard score, namely 70. Low concept mastery is partly due to difficulty understanding abstract concepts in physics which are difficult to visualize directly [4]. This is the background to the presence of different media in delivering physics learning. The role of instructional media is very essential in the learning process. Instructional media as a receptacle and transmitter of messages from the message source (educator) to the message recipient (students) [5]. Educators play a very important role in determining media where educators must choose instructional mediathat suits the material and student's needs [6]. If the instructional media used by educators is interesting, students will automatically like the material being taught and students' understanding of the material will be achieved more quickly.

An educator must be able to present innovation in the form of media that can encourage students' attention so that they can increase mastery of concepts. Learning designers can attract students' attention by using a variety of different media. Presenting all information in the same way is boring [7]. Various types of media used in presenting learning material can be multimedia. Multimedia is a combination of various media delivered using computers or electronic and digital equipment [8]. The meaning of interactive is the user's reciprocal communication with the media, starting from the user entering data and the media responding to the data so that an interaction is created [9]. Interactive multimedia development becomes easier by using the desktop-based Adobe Flash program which can combine text, images, graphics, sound, video, and animation into a multimedia program.

Research related to interactive multimedia includes a study by Gunawan et al. on the use of interactive multimedia in physics education and its implications for students' concept mastery. This study found that the use of interactive multimedia in physics education can enhance students' concept mastery compared to conventional methods [4]. Another study on the development of interactive learning media based on Macromedia Flash to improve students' concept mastery was conducted by Maherani et al. The results indicated that interactive media is effective in improving physics concept mastery [3]. The study conducted by Yanti et al. focused on the development of interactive multimedia accompanied by drills on the topic of pressure in junior high schools. The results of this study showed that the use of interactive multimedia with drills has a high level of effectiveness in helping students understand the material [10].

Various problems in physics learning were discovered from observations and interviews in the field, namely that learning still uses conventional methods which are dominated by lecture methods and very few lecturers use a variety of learning media; Most instructional media use presentation applications such as Microsoft PowerPoint. Apart from that, there is a perception among students that physics is a subject that is difficult to understand, less interesting, has lots of formulas, and is difficult to work on because it involves calculations. This condition causes low mastery of physics concepts. For this research, the organization involved in the development and validation of interactive multimedia included expert validators, researchers, and students, each contributing to different aspects of the research process. By implementing a systematic approach, the research was able to achieve its objectives and produce reliable and valid results that contribute to physics learning.

The expected benefits of this research on interactive multimedia are to motivate learning enthusiasm among users of physics learning software in general and electrical engineering students in particular. Reviewing the previously mentioned issues, this research aims to develop interactive multimedia for physics learning on electromagnetic induction material and to analyze its effectiveness in improving concept mastery.

Thus, this paper discusses the design and development results of interactive multimedia for physics learning on electromagnetic induction material. The multimedia design is expected to enhance concept understanding and be easy for students to use. The parameters considered in the design process refer to standard components to expedite the development process, such as interactive buttons, graphics, and audio-visual elements. The interaction process is reinforced by adding an intuitive user interface. The content presented is also aimed to be engaging for students.

2. RESEARCH METHODS

The study method uses the Research and Development method as stated by Sugiyono that the R&D method is used in research to create definite products and prove their effectiveness [11]. The product developed by researchers is interactive multimedia in the form of software. The effectiveness of interactive multimedia in this research was analyzed using a pre-experimental design. The design form in this study is a one-shot case study design. Fraenkel et al.'s statement regarding this design is that one group is given treatment then measures the dependent variable to assess the effect of treatment [5].

The steps of the Research and Development method refer to the adaptation model development procedures from Borg & Gall and Sukmadinata with three stages: preliminary study, product development, and product test [12]. Preparing a product design consists of four steps, namely determining the content of teaching materials, creating a flow diagram, creating a storyboard, and preparing a product draft.

This research was carried out at the Bogor Technology Academy for the 2023-2024 academic year with test subjects of 32 students from the electrical engineering study program. Meanwhile, the data collection strategy uses assessment sheets and pretest-posttest questions the data obtained was calculated using data analysis techniques with the help of Microsoft Excel.

In this research, the assessment scale uses a Likert scale with intervals ranging from 1 to 4. The data analysis technique is conducted based on the validation results from material experts and media experts. The material expert validation questionnaire instrument consists of 10 questions and the media expert validation questionnaire instrument consists of 20 questions consisting of four selected categories with the following criteria: Very Poor = 1, Poor = 2, Good = 3, and Very Good = 4.

After the answers are given by material and media experts, the scores obtained are added up and grouped and then assessed using the data analysis technique equation.

$$\text{Value} = \frac{\text{total score obtained}}{\text{total ideal score}} \text{ x } 100 \quad (1)$$

The scores obtained are in the form of percentages and then the ideal scores are converted into four assessment categories. The classification of assessment scores is shown in Table 1.

Table 1. Guidelines for Classifying Assessment Scores

Value	***Category***
76 - 100	*Very good*
51 - 75	*Good*
26 - 50	*Poor*
< 26	*Very Poor*

The table shows the guidelines for classifying assessment scores in the study. The assessment scores are divided into four categories: "Very good" for scores 76-100, "Good" for scores 51-75, "Poor" for scores 26-50, and "Very Poor" for scores below 26. These categories help in evaluating the validation of the developed interactive multimedia. Product revisions are carried out based on validation results and expert recommendations. The pretest-posttest results are used to calculate individual learning mastery using the following equation:

$$\text{Value} = \frac{\text{number of correct answer}}{\text{number of questions}} \text{ x } 100 \quad (2)$$

The individual learning completeness value is used to determine classical learning completeness using the equation:

$$\text{Classical learning completeness percentage (\%)} = \frac{\text{number of students who have completed their learning}}{\text{total number of students}} \text{ x } 100 \quad (3)$$

Interactive multimedia is declared effective if classical learning completeness is achieved where $\geq 85\%$ of students in the class (32 students) get a score ≥ 70.

3. RESULTS AND DISCUSSION

3.1 *Results*

3.1.1 *Preliminary Study Results*

In the literature study, a needs analysis was carried out by collecting data on theories related to interactive multimedia and physics learning, research methods, research and development models, course learning outcomes, and sub-course learning outcomes to determine the teaching materials that are the basis for product development. Field studies were conducted to see the application of physics teaching, optimizing the use of instructional media, as well as inhibiting and supporting factors.

In the field study, the results of identifying problems on campus were that students were less interested in studying physics because the learning method was still conventional and one-way. The majority of students stated that physics was a difficult course to understand, less interesting, had lots of formulas, and questions that were difficult to solve. The supporting factor on campus is the availability of computers can be used as a teaching and learning facility. This problem can be overcome by creating interactive multimedia for physics learning.

3.1.2 *Product Development Results*

Product development results consist of design development and product testing. Product development begins with determining the content of the material, creating a flow diagram and storyboard based on literature studies, then preparing a product draft. Interactive multimedia products developed using the Desktop-based Adobe Flash program. Teaching materials are physics learning materials which consist of material studying induced potential (GGL), Lenz's law, self-inductance, and applied electromagnetic induction in technology products. The resulting product contains text and audiovisual images, animation, and videos so that learning material is easier to understand and master by students. Below is presented the interactive multimedia display that was developed.

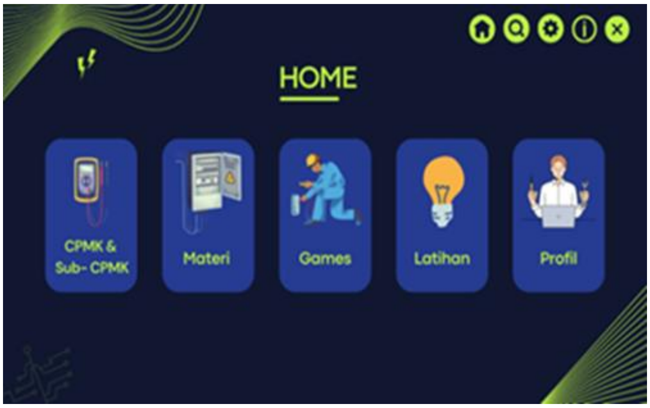

Figure 1. Title View

The figure shows the title view of the developed interactive multimedia. This title view is the initial screen that users see when they open the multimedia application.

Figure 2. Main Menu View

The figure displays the main menu view of the interactive multimedia. The main menu provides various navigation options for users to access learning materials, exercises, profiles, and other menus.

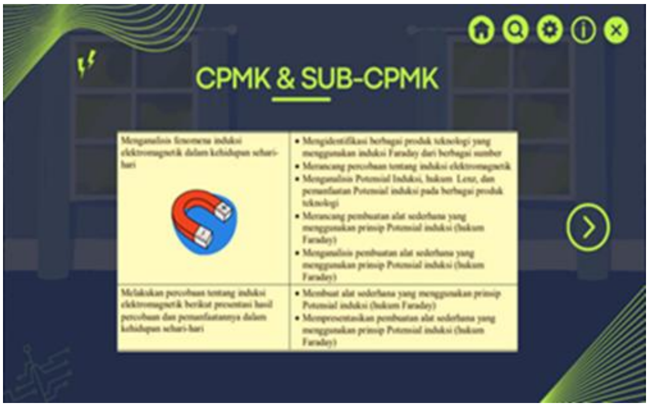

Figure 3. CPMK and Sub-CPMK Menu View

The figure shows the CPMK (Course Learning Outcomes) and Sub-CPMK menu view. This menu allows users to view and select specific learning subtopics within the electromagnetic induction material.

Figure 4. Teaching Material Menu View

The figure displays the teaching material menu view. In this menu, users can access various learning materials prepared in the interactive multimedia.

Figure 5. Exercise Menu View

The figure shows the exercise menu view, where users can work on practice questions to test their understanding of the material they have learned.

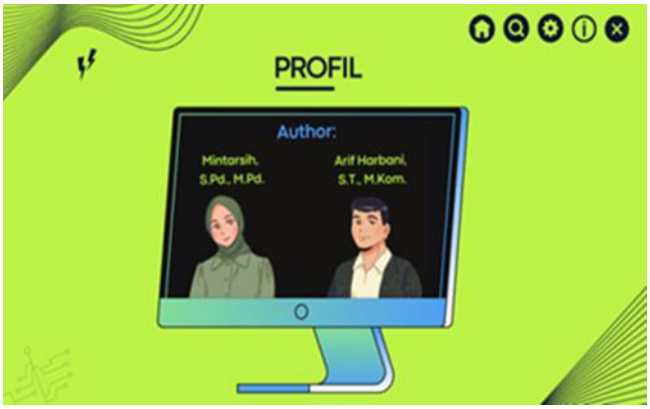

Figure 6. Profile Menu View

The figure displays the profile menu view, where users can see the author's personal information and find contact persons who can be reached.

In product trials, material experts assessed interactive multimedia in terms of learning materials. The material assessment sheet contains material and technical aspects. Media experts assess interactive multimedia in terms of its presentation. The media assessment sheet contains design and program aspects. Interactive multimedia validation analysis results are presented in the table below.

Table 2. Results of Interactive Multimedia Validation by Material and Media Experts

No	*Aspects*	*Value (%)*	*Category*
1	*Material*	*94.05*	*Very good*
2	*Media*	*96.25*	*Very good*
Average score		*95.15*	*Very good*

The table presents the results of the validation of interactive multimedia by material and media experts. The aspects assessed include material and media aspects with respective scores of 94.05% and 96.25%, all falling under the "Very good" category. The overall average score is 95.15%, indicating a very good validation.

3.1.3 *Product Test Results*

The final product trial was carried out at the Bogor Academy of Technology on students of the Electrical Engineering Study Program by giving concept mastery tests. Objective tests as question instruments have been tested for validity and reliability. The results of data analysis are presented in the image below.

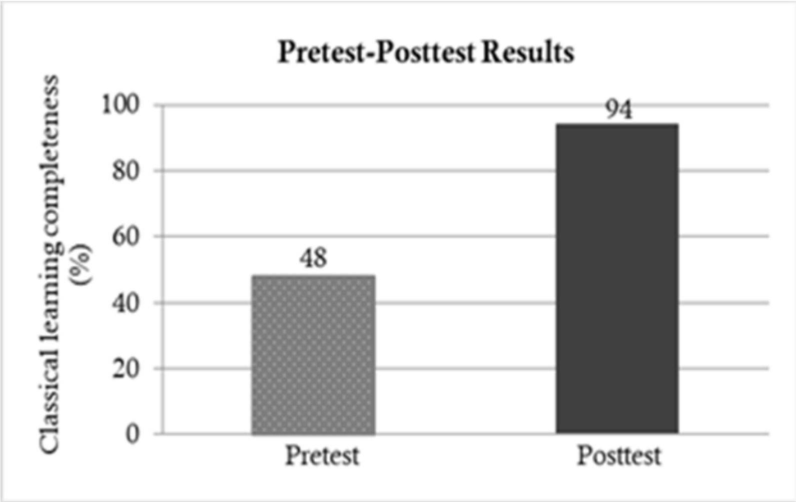

Figure 7. Diagram of the increase in classical learning completeness

The figure presents a diagram of the increase in classical learning completeness. The diagram shows a comparison of pretest and posttest results to assess the improvement in concept mastery after using interactive multimedia. The diagram illustrates that classical learning completeness increased from 48% to 94%, demonstrating the effectiveness of the interactive multimedia in enhancing concept mastery.

3.2 *Discussion*

The resulting product contains text and audio, supported by images, videos, and animations, making it easier for students to understand physics learning. Based on the material assessment, this product is categorized as very good, and the interactive multimedia can be used for product testing. Comments from material experts who say the media is very interesting, increasing students' enthusiasm, and attention to learning. The use of instructional media can speed up the learning activity and help speed up students' understanding of the material provided because using media will attract students' attention [6]. Based on the product assessment from the media aspect it is categorized as very good, interactive multimedia can be used in product testing. Media expert comments state that the design is good because it is very attractive with dynamic buttons, therefore users can communicate and interact. This is in accordance with Yudhistira's opinion that interactive multimedia is the use of computers to combine text, images, graphics, sound, animation and video with the right tools and links so that users can interact, navigate, create and communicate [13].

Interactive multimedia has the ability to interact with users, with a design focused on conveying information so that users can interact actively and get the content they need [14]. Good media is media that is able to provide interactive two-way communication [15]. Validation results from experts show that the interactive multimedia category developed is very good. The validation results are in accordance with previous studies. Even, the product validation results in this study were higher, namely 95.15% compared to Yanti et al.'s research results of 88.65% [10].

Based on data analysis of posttest results, physics learning on electromagnetic induction material using interactive multimedia experienced an increase in classical learning completeness. The posttest results in the product trial class (see Figure 7) obtained classical learning completeness of 94%. Thus, there was an increase of 46% from the initial classical learning completeness of 48%. Classical learning completeness of 94% has met the criteria to be achieved in the research. Therefore, interactive multimedia for physics learning on electromagnetic induction material has been developed effectively in increasing concept mastery. Similar research carried out by Gunawan et al. shows that students' concept mastery taught using interactive multimedia instructional is higher than those taught using conventional methods [4]. Likewise, research carried out by Maherani et al. shows that interactive instructional media is effective in increasing students' mastery of physics concepts [3].

From the results and discussion above, the research aims to produce interactive multimedia for physics learning on electromagnetic induction material has been achieved.

4. CONCLUSION

Interactive multimedia for learning physics on electromagnetic induction material for electrical engineering study program students has been successfully developed using the Research and Development method steps referring to the adaptation model development procedures from Borg & Gall and Sukmadinata through three stages, namely preliminary study, product development, and product test.

Interactive multimedia validation results of 95.15% are included in the very good category and classical learning completeness of 94% has met the criteria to be achieved in the research. Thus, interactive multimedia for physics learning on electromagnetic induction material is very good and effective in improving mastery of concepts so that it can be used in physics learning activities.

For future research, it is expected to develop interactive multimedia for physics learning on other topics to assess the consistency of its effectiveness in improving concept mastery. Additionally, comparative studies should be conducted to compare the effectiveness of interactive multimedia with other teaching methods, such as project-based learning, to gain further insights into the most effective teaching strategies.

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