Effect of Developing Multimedia for Three Phase Induction Motor Rewinding Using ADDIE Model

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Abstract
Motor rewinding skills are one of the practical skills of an electrician. Generally, it will be organized as a vocational certificate program, emphasizing practical training in disassembly and reassembly motors, form coils of copper wire and electrical circuit connections. Over the course of the last few years, there has been a there has been a decline in learning and proficiency in practice capabilities due to the pandemic. Utilizing media technology in the classroom facilitates practice by letting students' study and work through material independently. As a result, the Addie model is used in the research to create multimedia materials for motor rewinding. The results of the study found that: 1) Develop multimedia to enhance skills in three-phase induction motors according to the ADDIE Model concept. The multimedia was examined by three experts, and 2) results of finding the quality of developing multimedia to create skills in three-phase induction motors according to the ADDIE model. Regarding the appropriateness of the contents of disassembling a three-phase induction motor, the experts had a high overall opinion ($\overline{X}$=4.11, S.D.=0.93). The overall development of learning outcomes from the content structure of three-phase induction motors was rated highly ($\overline{X}$=4.5, S.D.=0.56). The psychomotor domain was at the skill movements level, while the cognitive domain was at the comprehension level. In the development of multimedia media to increase learning skills regarding three-phase induction motors according to the ADDIE Model can be used as teaching media and can also allow students to study outside of class time appropriately, which will affect their learner development according to the ADDIE Model.

Keywords: ADDIE Model, Developing Multimedia, Motor Rewinding, Three Phase Induction Motor

Introduction

Currently, where digital technology is a big part of our everyday lives, creating engaging and effective learning materials is crucial. Consequently, the deployment of simple-to-understand media technology, which combines words, images, sounds, and videos for independent training and practice, can enhance learning. The earlier reports (Ye, 2000) exemplify the utilization of multimedia in teaching to enhance students' understanding and engagement, be it in business models, science, engineering, or any other subject (Doni, 2023; Gabriel, 2023; Pramudita, 2018). Multimedia is often applied to technically complex subjects where learners have little ability to understand the lesson and practice, and multimedia is often created about practical skills that make the skill more proficient, such as the technique of winding a 3-phase induction motor, which is considered one of the most important practical skills of all electricians and requires extensive training. Focusing on the fundamentals of motor winding, motor disassembly, winding copper form coils, installing coils in the stator motor, connecting the motor's electric circuit, and assembling the electric motor, particularly in the group of vocational certificate students grouped in the practical electrical machine subject. Nevertheless, the epidemic has made it impossible to exercise practical skills in the laboratory in recent years. Students may receive no practice, only online instruction, a change in the structure of instruction, or none at all, leaving them without any practical skills. These skills have declined as a result of a learning regression.

Since induction motors are the key components that drive the machinery and manufacturing processes in the industry, education and training in induction motor winding are vital. Numerous industrial sectors, including manufacturing, energy, transportation, and electrical appliances, employ induction motors. Consequently, it is critical to ensure the motors operate safely and effectively. Because winding an induction motor includes several intricate and exact processes, each of which is crucial to the motor's operation, it is a procedure that calls for specific knowledge, experience, and extreme caution. Any errors might lead to the motor breaking down or performing poorly. Thus, systematic motor winding training equips students with the information and abilities needed for real-world work, which is crucial for advancing professional talents and enhancing the working capacities of engineers and electricians (Masoumi, 2022). Possessing the right information and abilities for motor winding also lowers the possibility of mishaps and equipment damage, which boosts productivity and lowers maintenance and replacement expenses. Furthermore, high-quality education and training may help to develop skilled workers who can produce new inventions and technologies for the industry. In the long run, developing these employees will support the industry's growth and competitiveness.

One of the techniques that can be used to design and develop multimedia in the motor winding process for efficiency is the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) technique, which is an instructional design process that emphasizes analysis, design, development, implementation, and evaluation (Aldoobie, 2015). Because it offers a precise and organized framework that makes learning media creation efficient and student-centered, the ADDIE model is one of the most well-liked and often applied instructional design models globally (Sahaat, 2019; Spatioti, 2022). Every stage of the model—which includes analyzing learners and their content learning needs, designing and planning instruction, choosing tools and technologies, producing and testing multimedia content, setting up equipment, overseeing and assisting instruction, assessing instruction, and refining the quality of the media—contributes significantly to the creation of high-quality learning materials (Budoya, 2019). Therefore, this article focuses on using the ADDIE Model

concept to develop multimedia for teaching three-phase induction motor winding. This model enables the creation of learning media that are systematic and effectively respond to learners' needs. The developed media will help learners understand and learn complex subjects more effectively and interestingly. The design focuses on responding to learners' specific needs and continuous improvement.

This research presents a study on the development of multimedia materials for motor winding using the ADDIE model, which consists of five steps in designing and developing learning processes through multimedia. The aim is to enhance learners' understanding and align with 21st-century skills (Binkley, 2012). The multimedia integrates visual, auditory, and explanatory elements to improve the learning and comprehension of motor winding. The study evaluates the impact of the developed multimedia on learners in three areas: 1) professional skills, 2) learning skills, and 3) positive attitudes. Additionally, it compares the multimedia-based learning process with teacher-centered methods that focus on motor-winding content. The research highlights the creation of effective tools for both teachers and students, enhancing understanding of motor winding processes, which will significantly benefit future industrial and technological development.

ADDIE Model

The ADDIE Model allows for continuous adaptation and development, ensuring effective learning that aligns with learners' needs. The ADDIE model is popular because of its flexibility and the freedom it gives instructors in designing and developing web-based teaching (McGriff, 2000). This model consists of five key stages:

Analysis: The first stage focuses on gathering and analyzing information about learners, as well as the content and potential issues. Instructors must understand the target audience, including their prior knowledge, interests, and learning goals.

Design: Instructors use the information from the analysis to design the lesson. Instructors will define lesson objectives, structure content, and create learning activities. They will also select appropriate teaching media to help learners achieve the goals.

Development: This stage entails the creation of the designed content and instructional materials. It includes writing scripts or storyboards, creating graphics, audio, and video elements, followed by testing and refining to ensure the lesson works effectively.

Implementation: After development, we put the lesson into practice. This could include testing it with students or using it in a real-world setting to assess its effectiveness.

Evaluation: The final stage assesses the effectiveness of the lesson. It includes formative evaluation during development to make improvements and summative evaluation after implementation to gather data for future development.

The entire process is adaptable, allowing for modifications as needed to ensure that teaching is efficient and meets the specific needs of learners in various contexts

Designing Multimedia on Induction Motor Winding Based on the ADDIE Model

Due to issues observed during practical induction motor winding, where students often failed to plan the winding sequence properly, causing delays and missed deadlines, this research

employs Kruse's (Kruse, 1999) design and development principles. These principles follow the systematic ADDIE Model, which consists of five stages, as outlined below:

Analysis: This stage concentrates on analyzing learner information and requires alignment of the multimedia content with the target audience and learning objectives. Examples include:

- Target learners: Electrical engineering students or those working in the electrical field.
- Prior knowledge: Students should have a basic understanding of induction motor operation.
- Objectives: Learners should understand how to wind an induction motor and perform the task correctly.
- Challenges: While learners may understand the theory, they often lack practical skills, so the media should emphasize hands-on practice.

Design: This stage involves structuring and designing multimedia content.

- Learning objectives: Focus on ensuring learners understand and follow the motor winding process.
- Content layout: Start with an explanation of induction motor theory, followed by motor winding procedures.
- Learning Activities: The multimedia should include virtual motor winding simulations for learners to practice.
- Media selection: Use graphics, instructional videos, and audio narration to explain each step.
- Presentation plan: Structure the lesson from theory to practical application.

Development: At this stage, the design plan guides the development of the actual multimedia content. Scripting is the process of writing scripts and creating storyboards for each content section.

- Multimedia creation: developing graphics, videos, and interactive simulations for learners, integrating visuals, audio, and text.
- Alpha testing: testing the multimedia with experts to identify and fix any issues.

Implement: This phase involves the use of multimedia with actual learners.

- Teaching and usage: Students use the multimedia to learn and practice motor winding.
- We check the effectiveness and make the necessary adjustments.

Evaluation: At this stage, the success of the multimedia is evaluated.

- Learner assessment: Evaluate through both theoretical and practical exams.
- Feedback: Gather input from students and instructors to improve the multimedia for future use.

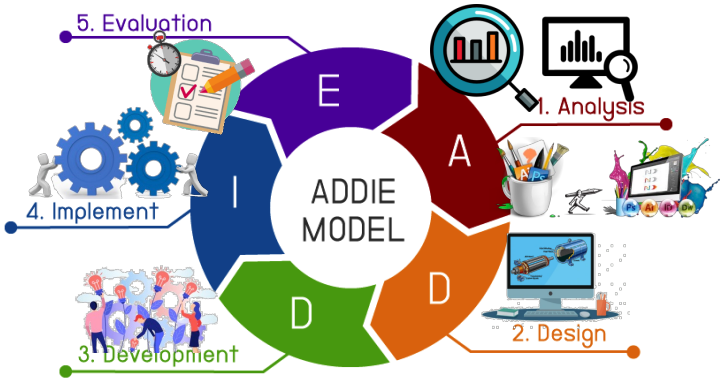

Figure 1: Using the ADDIE Model to Design Multimedia on Induction Motor Winding

Results of Teaching Design in Three-Phase Induction Motor Using ADDIE Model

The presentation of instructional design principles for three-phase induction motor rewinding following the ADDIE model requires effective implementation through systematic analysis, design, development, implementation, and evaluation. The outcomes for each step are as follows.

Analysis Results Using ADDIE Simulation Approach for Three-Phase Induction Motor Winding

In recent years, the pandemic has caused a decline in hands-on skill training, leading to gaps in practice. Furthermore, universities and educational institutions that offer practical courses in motor rewinding have reduced the number of practice hours due to the introduction of new courses. Mismatched schedules between instructors and students have resulted in frequent changes to class times, giving students less time for learning and practice. To address this issue, the use of multimedia technology can enhance the effectiveness of teaching and learning. Students can access and benefit from course content anytime and anywhere, allowing them to learn independently before engaging in actual hands-on practice.

In terms of learner analysis, the target group consists of undergraduate students in Electrical Engineering Education who already have basic electrical knowledge. This allows for the development of foundational lessons specific to electrical work that can help students review and practice three-phase motor rewinding, as well as test their learning outcomes after completing the course.

Design Results Using ADDIE Simulation Approach for Three-Phase Induction Motor Winding

We divide the learning objectives into terminal objectives and enabling objectives. The terminal objectives refer to what students should achieve after the teaching process, while the enabling objectives indicate what students gain during the study of the lesson. The content must follow proper procedures. As for the media used in teaching, the content, students' needs for learning resources, and the specific requirements for the “Electrical Engineering Skill” subject were considered. Problems identified during the process led to the development of multimedia using the ADDIE model. This process led to the creation of an animation video, which starts by demonstrating the steps involved in dismantling the motor's end caps, removing the rotor from the stator, extracting the coil from the motor's frame, inserting insulation paper into the motor slots, winding of 12 form coils, installing the coil sets into the stator, connecting the wiring, and reassembling the motor. This multimedia content is 6 minutes and 3 seconds long, featuring animations and graphics with narration.

The content must align with the learning outcomes of the "Electrical Engineering Skill" subject, and the terminal objectives are set for students to learn and practice induction motor rewinding. Moreover, they should be able to apply this knowledge in their daily lives.

The learning management plan emphasizes enabling students to perform motor rewinding according to the step-by-step learning process from the multimedia lesson on three-phase induction motor rewinding. Students are encouraged to learn in advance before engaging in hands-on practice. This approach helps students plan and perform motor rewinding in a

shorter period. We found that rewinding a motor without multimedia support took 7 hours, while using multimedia reduced the rewinding time by 4 hours.

The age of students is a factor affecting motor rewinding practice. The first-year Electrical Engineering Education students consist of two groups: vocational students and general education students, each with different levels of specialized knowledge. Therefore, it is essential to design detailed lessons that enable all students to follow the multimedia motor rewinding steps.

Regarding motor rewinding exercise, the students have favorable attitudes and confidence. As a result, students like their work, feel comfortable expressing themselves, make judgments without worrying about making a mistake, and prepare methodically.

Development Results Using ADDIE Simulation Approach for Three-Phase Induction Motor Winding

The design and production of multimedia materials, lessons, and content fall into eight main categories: 1) remove a cover motor, 2) removing the rotor from the stator, 3) taking out the coil from the motor's stator frame, 4) folding and inserting insulation paper into the motor slots, 5) winding of 12 form coils, 6) installing the coil sets into the motor's stator, 7) connecting the wiring, and 8) reassembling the motor. We incorporate each part of the content into a narrative format that narrates the story of motor rewinding. This step is crucial because the lesson's appeal and ability to stimulate student interest in learning depend on how the designer presents the material and selects appropriate media for the lesson's content. Following this, the designer invites experts and students, who are the end users, to provide their feedback on the materials for further enhancement and development.

Implementation Results Using ADDIE Simulation Approach for Three-Phase Induction Motor Winding

A group of undergraduate students in the Electrical Engineering Education program trialed the use of multimedia materials in teaching to identify potential errors and gather suggestions for improvements. Initially, the instructor should conduct one-on-one evaluations, allowing individual students to consider any issues they encounter while using the lesson. The instructor can interview students or ask them to express their opinions while engaged with the lesson, using the problems identified to enhance it. Next, conduct a small group assessment with 3-5 students to test the created lesson and observe their interaction and assistance needs. The instructor will use the gathered information to refine the multimedia lesson on motor rewinding and forecast its effectiveness for larger groups in the future.

This evaluation will involve having all students in the class participate in learning using the improved lesson. Students can learn from the created lesson by integrating ongoing assessments into the teaching process. After the lesson, students must take a quiz to determine whether they have met the learning objectives. If there are any shortcomings in achieving the objectives, we can use that information to improve and enhance the web-based teaching for better effectiveness. This research focuses on the development of multimedia learning materials on three-phase induction motor rewinding using the ADDIE process for media development. The sample population consisted of 97 first-year Electrical Engineering Education students from King Mongkut’s University of Technology Thonburi. The study included the entire population, with the inclusion criteria being: 1) students enrolled in the

"Electrical Engineering Skill" subject during the second semester of the 2023 academic year, and 3) students who could participate in the project throughout its duration. The exclusion criteria were: 1) failure to complete the practical sessions and knowledge tests, 2) incomplete or insufficient data responses, and 3) illness during the project at its conclusion.

Evaluation Results Using ADDIE Simulation Approach for Three-Phase Induction Motor Winding

This study checks and measures outcomes in two areas: the quality of multimedia materials about taking apart three-phase induction motors and the growth of learning outcomes based on the motors' structural content. Evaluators include experts in electrical engineering from technical colleges and specialists directly involved in motor rewinding (motor winders), as well as students who take knowledge assessments to improve learning outcomes.

1) Evaluation Results of the Quality of Developing Multimedia to Create Skills in Three-Phase Induction Motors

We used the ADDIE process to evaluate the multimedia materials for the disassembly content of three-phase induction motors, with a focus on the following criteria:

- Content Accuracy and Relevance
- Clarity of Presentation
- Aesthetics and Visual Appeal
- Audio and Visual Quality
- Accessibility
- Alignment with Instructional Principles
- Usability and Functionality

The evaluation of the quality of multimedia materials for the content on disassembling three-phase induction motors revealed that, overall, experts rated the quality of the materials highly, with an average mean score of 4.11 and a standard deviation (S.D.) of 0.93. Particularly in the area of content accuracy and relevance, the highest score was 4.4, with a standard deviation of 0.83. This indicates that the content is reliable and aligns with academic standards, making it suitable for the students' knowledge level. The content follows a clear sequence that aligns with the learning objectives.

Table 1: Results of the Quality Evaluation of the Multimedia Content of the Disassembly of Three-Phase Induction Motor

Quality of Multimedia Content	$\overline{X}$	**S.D.**	**Opinion Level**
Content Accuracy and Relevance	4.40	0.83	High
Clarity of Presentation	4.12	0.91	High
Aesthetics and Visual Appeal	4.00	0.92	High
Audio and Visual Quality	4.30	0.90	High
Accessibility	3.90	0.93	High
Alignment with Instructional Principles	3.80	0.96	High
Usability and Functionality	4.30	0.95	High
Average	4.11	0.93	High

However, alignment with instructional principles received the lowest score of 3.8, suggesting that further improvements are necessary in this area to better match teaching principles.

Generally, practical courses emphasize hands-on experience for first-year students, leading to a lack of connection between theory and practice.

2) Evaluation Results of Learning Outcomes From the Content on the Structure of Three-Phase Induction Motors

In this research, the quality of the content of the multimedia materials on winding three-phase induction motors was tested using the ADDIE development process. The content includes disassembling the end caps of the motor, removing the rotor from the stator, taking out the windings from the stator frame, folding and inserting insulation paper into the motor slots, winding of 12 form coils, installing the coil sets in the motor stator, connecting wires, and assembling the motor frame. For each content area, students were required to take a post-test after using the multimedia materials to evaluate the quality and understanding of the content related to three-phase induction motors, as shown in Table 2. We divided the learning content into eight topics to assess students' understanding, providing a clear view of the learning outcomes in the psychomotor domain (6 topics) and the cognitive domain (2 topics), specifically the winding of 12 form coils and the wiring.

Table 2: Results of the Evaluation of the Development of Learning Achievement Fromthe Content of the Structure of Three-Phase Induction Motor

Content of Three-Phase Induction Motor Winding	$\overline{X}$	**S.D.**	**Opinion Level**
Remove a cover motor	4.4	0.56	High
Removing the rotor from the stator	4.6	0.58	High
Taking out the windings from the stator frame	4.8	0.51	High
Folding and inserting insulation paper into the motor slots	4.5	0.56	High
Winding of 12 form coils	4.3	0.61	High
Installing the coil sets in the motor stator	4.1	0.61	High
Connecting wires	4.6	0.60	High
Assembling the motor frame	4.8	0.48	High
Average	4.5	0.56	High

From the evaluation of the development of learning outcomes based on the content regarding the structure of three-phase induction motors, the overall average learning achievement was found to be 4.5, with a standard deviation of 0.56, indicating a “high” level of opinion. This aligns with the results of the quality assessment of the multimedia content for disassembling three-phase induction motors, demonstrating that students can develop learning outcomes in the psychomotor domain at the level of skill movements and in the cognitive domain at the level of comprehension (Begam, 2018). This was measured based on the topics of winding 12 form coils and wiring. There was variability in the levels of achievement, with standard deviations of 0.56 and 0.60, respectively, in skill movements. This indicates that the difficulty in practice, particularly in the processes of folding paper and inserting insulation paper, may require precision and accuracy, as the dimensions should not exceed the slots. Therefore, students felt that these tasks were more challenging compared to other content areas.

Conclusion: Summary of Results

This study focused on the development of multimedia resources to enhance skills in winding three-phase induction motors by utilizing the ADDIE Model for media creation. The quality

of the multimedia content for disassembling three-phase induction motors was assessed by experts, highlighting the appropriateness of the content, which received an average score of 4.11 (S.D.=0.93). This indicates that the content is suitable and meets the objectives of disassembling three-phase induction motors. The average score for the development of learning outcomes from the content on the structure of three-phase induction motors was 4.5 (S.D.=0.56), indicating that students were able to develop learning outcomes in the psychomotor domain, specifically in skill movements, and in the cognitive domain, specifically in comprehension. Therefore, motor winding skills are essential for electricians and are typically taught at the vocational certificate level and within electrical education programs, which emphasize hands-on training. However, the integration of multimedia technology into the learning process can serve as an effective tool for training and learning. The developed multimedia resources not only enable students to learn motor winding skills during class time but also allow them to study further outside of class. This will enhance their understanding and proficiency in practical work.

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