Development of Innovative Learning Resources Using Project-Based Electric Transient Analysis Program (ETAP) in Learning the Use and Control of Electric Motors in the Electrical Engineering Education Study Program, Faculty of Engineering, Unimed

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Abstract. This study aims to develop innovative project-based learning resources using the Electric Transient Analysis Program (ETAP) for the Motor Use and Control course in the Electrical Engineering Education Program. The research subjects were undergraduate students. The study was conducted over one year and consisted of three main stages: (1) analysis of learning resource needs and identification of an appropriate learning model; (2) development, validation, limited trials, and finalization of the innovative learning resources; and (3) implementation of ETAP-based project-based learning using a KKNI-oriented instructional design with six structured assignments and Outcome-Based Education (OBE) principles. The results show that the developed project-based learning resources are valid, feasible, and practical for use in teaching and learning activities. The application of ETAP through the Direct Online Learning (DOL) method improved student learning outcomes, as indicated by an increase in pretest and posttest scores. Furthermore, classroom and laboratory implementation demonstrated that the learning model was effective in enhancing students' understanding of electric motor use and control.

Keywords: project-based learning, ETAP, electric motor control, learning resources, electrical engineering education

1 Introduction

Graduates of higher education are required to possess a balanced set of competencies, including academic knowledge, higher-order thinking skills, managerial abilities, and communication skills. A deficiency in any of these competencies may reduce the overall quality of graduates. The integration of these skills is reflected in graduates' ability to quickly and effectively solve problems encountered in professional and real-life contexts. Consequently, stakeholders demand higher education institutions to continuously improve educational quality by effectively managing their organizational

roles in responding to global competition in education [1]. Quality education can be defined as the level of excellence in educational management implemented effectively and efficiently to produce competent graduates who successfully complete a specific level of education [2].

High-quality learning strategies are essential to produce graduates who are faithful, productive, creative, innovative, and affective individuals, as well as responsible citizens capable of contributing to societal and national development [3–4]. Therefore, the quality of education must be continuously improved to anticipate changes in labor market demands. This improvement can be achieved through the provision of quality learning resources that align with technological advancements, learner needs, and curriculum requirements [5–8]. The rapid development of information and communication technology in education has also shifted learning paradigms toward independent and student-centered learning [9]. As a result, learning innovation is increasingly necessary to support faster, more efficient, and more effective learning processes [10,11]. Achieving graduate competencies and fostering critical thinking skills have become key objectives in higher education learning [12].

In the context of electrical engineering education, the Motor Use and Control course plays a crucial role in equipping students with both theoretical understanding and practical skills related to electric motor operation and control systems. To support these learning outcomes, innovative learning resources that integrate technology and active learning models are required. This study focuses on the development of project-based innovative learning resources using the Electrical Transient Analysis Program (ETAP) for the Motor Use and Control course.

ETAP is a software application widely used for electric power system analysis and simulation. It can be operated offline for system simulation, online for real-time data management, or applied for real-time system control. Several motor control methods can be simulated using ETAP, including Direct Online (DOL), Wye-Delta, Stator Resistor, and Voltage Control (Soft Starter). Each method has specific characteristics and advantages depending on load conditions and application requirements. In this study, the Direct Online (DOL) method was selected due to its simplicity and ease of implementation in instructional settings [13].

Project-Based Learning (PBL) is a learning model that begins with real-world problems or projects as a foundation for acquiring new knowledge through meaningful learning activities. PBL provides concrete learning experiences that encourage students to engage in higher-order thinking, develop problem-solving skills, and practice decision-making in realistic contexts [14]. Moreover, this learning model emphasizes collaboration and cooperation among students, fostering innovation, creativity, and a strong orientation toward problem-solving. Therefore, integrating ETAP with a project-based learning approach is expected to enhance the effectiveness of learning in the Motor Use and Control course.

2 Method

This study employed a mixed-methods approach combining survey, exploratory, and experimental methods across the stages of development, standardization, and implementation. The survey method was used to standardize the project-based learning resources through a structured questionnaire developed by the research team. The survey aimed to gather expert and user feedback on the quality of the learning resources in supporting KKNI-oriented curriculum competencies, including aspects of material organization, depth of content, relevance of instructional innovation, and the use of interactive and multimedia elements to support lectures.

Exploratory research was conducted to identify and analyze relevant learning modules, instructional media, and appropriate active learning strategies to support the development of project-based learning resources. Furthermore, an experimental method was applied to evaluate the effectiveness of the

developed learning resources. This stage aimed to determine the impact of the learning resources on student learning outcomes after implementation in classroom and laboratory settings.
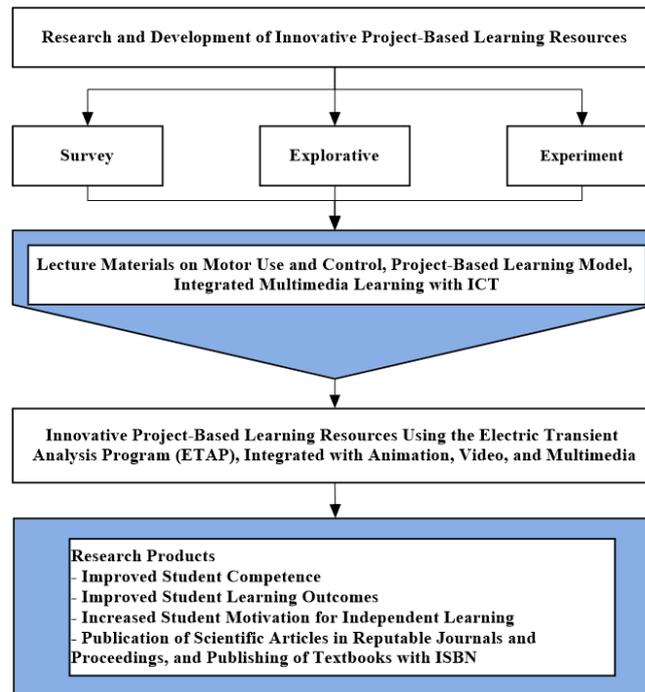

Figure 1. Research Design of Innovative Project-Based Learning Resources to Improve Student Learning Outcomes in the Motor Use and Control Course.

Data were collected using questionnaires and learning outcome tests. The feasibility of the developed learning modules and instructional media was evaluated by subject-matter experts and learning media experts. Effectiveness was measured by analyzing students' learning outcomes through a one-group pre-test–post-test design. The improvement in learning outcomes was determined by calculating the normalized gain (N-Gain) score based on the comparison of pre-test and post-test results.

3 Results and Discussion
3.1 Research Results and Discussion
3.1.1 Eligibility Module Learning
The results of the feasibility assessment of the learning module on the use and control of electric motors are presented in Table 1. The feasibility evaluation was conducted through expert validation to assess the suitability of the module for instructional use.

Table 1. Expert Validation Results of Learning Module Feasibility

No	Aspect Which Rated	Validator		MarkFlat
		1	2	Flat
1	Contents	3.70	3.61	3.65
2	Presentation	3.75	3.75	3.75
3	Appearance	4.00	4.00	4.00
4	Linguistics	3.67	3.67	3.67
				3.77

Based on the data presented in Table 1, the average score across all aspects of the learning module feasibility assessment is 3.77. Referring to the predetermined feasibility criteria, this mean score falls within the "very feasible" category. Therefore, it can be concluded that the learning module on the Use and Control of Electric Motors is highly suitable for use as a learning resource in the instructional process.

3.1.2 Eligibility Media Learning
The results of the feasibility assessment of the learning media for the use and control of electric motors are presented in Table 2. The feasibility evaluation was conducted through expert validation to determine the suitability of the learning media for instructional use.

Table 2. Expert Validation Results of Learning Media Feasibility

No	Aspect Which Rated	Validator		MarkFlat
		1	2	Flat
1	Appearance	4.0	3.67	3.83
2	Ease of Use	3.75	3.75	3.75
3	Graphics	4.00	4.0 0	4.00
4	Serving	3.75	4.00	3.87
5	Media Content Design	3.6 0	3.80	3.70
				3.83

Based on the data presented in Table 2, the average score across all aspects of the learning media feasibility assessment is 3.83. Referring to the predetermined feasibility criteria, this mean score falls within the "very feasible" category. Therefore, it can be concluded that the learning media for the Use and Control of Electric Motors is highly suitable for use in the learning process.

3.1.3 Effectiveness of Learning Outcomes
Based on the results of learning outcome tests in the Use and Control of Electric Motors course, the effectiveness of the developed learning modules and ETAP-based learning media was analyzed using the normalized gain (N-Gain) score. The findings indicate that the use of the modules and learning media supported by ETAP is moderately effective. The calculated N-Gain score was 0.56, which corresponds to 56% in percentage form. According to the established N-Gain criteria, this result falls within the medium effectiveness category, indicating an improvement in students' learning outcomes after the implementation of the developed learning resources.

The distribution of students' learning outcome improvement based on the normalized gain (N-Gain) score is presented in Table 3.

Table 3. Distribution of Learning Outcome Improvement Based on N-Gain Score

Number	Percentage (%)	Estimate
1	$g > 7$	Tall
2	$0.3 \leq g \geq 0.7$	Currently
3	$g < 0.3$	Low

Source: Meltzer (as cited in Syahfitri, 2008)

Based on the calculation, the obtained normalized gain (N-Gain) score was 0.56. Referring to the estimated gain score categories presented in Table 3, this result indicates that the use of ETAP in the developed learning modules and media falls within the medium effectiveness category [15]. The distribution of N-Gain categories expressed in percentage form is presented in Table 4.

Table 4. Distribution of N-Gain Categories

Number	Percentage (%)	Estimate
1	< 40	Ineffective
2	40 – 55	Less Effective
3	56 – 75	Quite Effective
4	> 75	Effective

Source: Hake, R. R. (1999)

Based on the N-Gain score expressed in percentage form, the obtained result was 56%, which corresponds to an N-Gain value of 0.56. Referring to the N-Gain category criteria presented in Table 4, this result indicates that the use of ETAP in the developed learning modules and media falls within the medium effectiveness category [16]. This finding is consistent with Hake's classification, which states that N-Gain values in the range of 0.3–0.7 reflect a moderate level of learning improvement resulting from instructional interventions.

The medium effectiveness achieved in this study suggests that the integration of ETAP with project-based learning contributes positively to students' understanding of electric motor use and control. The use of simulation-based software such as ETAP enables students to visualize system behavior, analyze operational conditions, and apply theoretical concepts in practical contexts, which supports deeper conceptual learning. Previous studies have reported that technology-supported project-based learning can effectively enhance learning outcomes, particularly in engineering education, by promoting active learning, problem-solving skills, and meaningful engagement with course content [14–16]. Therefore, the results of this study confirm that ETAP-based project learning is an effective instructional approach for improving student learning outcomes at a moderate level and has the potential to be further optimized in future implementations.

4 Conclusion

Based on the results of the study, it can be concluded that the ETAP-based learning module and instructional media developed for the Use and Control of Electric Motors course are feasible and suitable for instructional use. Expert validation results indicated that both the module and learning media met the criteria for high feasibility. Furthermore, the effectiveness analysis showed that the ETAP-based module and media achieved a medium level of effectiveness in improving student learning outcomes.

Therefore, the developed learning resources can be utilized as alternative instructional instruments in the learning process of the Use and Control of Electric Motors course. Future implementation and refinement of these resources are expected to further enhance learning effectiveness and student competence.

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