



Project-Based Module Development in the Electrical Circuit Course

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Abstract: Education is one of the efforts of awareness to realize cultural inheritance from past generations to new generations. Vocational education must prepare graduates who are easily absorbed by the industrial world and the business world, specifically for solving this problem, one solution is improving the learning model. The project-based learning model is able to form soft skills, gain knowledge to solve problems critically and creative thinking skills. The results of the research carried out were obtained, among other things, from each material validation statement, the experts stated that the module was valid and suitable for use. The results of media expert validation showed that the module was declared media valid. The response of lecturers in the electrical circuits course to the electrical circuits learning module gave a good response, namely the practicality level of the module was 78%, where the module was declared practical. A questionnaire distributed to students taking the Electrical Circuits course with 10 statements stated that the module received a score of 80%, where a score of 80% indicated that the module they used was practical for learning the Electrical Circuits course. The analysis carried out to see the results of the Paired T Test obtained a significant level of $0.000 < 0.05$ which shows that there is a significant difference between the pretest and posttest results. It was concluded from this effectiveness test that there was a difference in the results before and after receiving treatment using Project-based Module Development in the Electrical Circuits Course.

Keywords: Development; Electrical Networks I; Learning Modules

Introduction

Education is one of the efforts stemming from awareness to realize the cultural heritage from past generations to the new generation (Pérez-Guilarte et al., 2023; Arnica et al., 2023). Education actually has no limits to explain the meaning of education because it has a complex meaning. However, in a simple and general sense, the meaning of education is human efforts to nurture and enhance one's abilities or potential in line with the values that already exist in society and culture. Education in daily life has several types, namely formal and non-formal education, as well as general education and vocational education (Manurung et al., 2021). Vocational education, also often referred to as vocational education, is education that prepares its students to be

ready for employment after graduation with the vocational knowledge they possess. Therefore, vocational education has the same meaning as vocational education. Vocation or commonly referred to as vocational education is education that directs students to master specific skills in preparing them to enter the workforce.

Vocational education plays an important role in advancing its competent graduates in the industry (Subiyantoro et al., 2023; Wahyuni et al., 2018). Fierce market competition demands that vocational education graduates not only have the ability to work competently but also have the ability to create products with innovative value. The expected learning to achieve the goals of education is creative, innovative, collaborative, and student-centered learning. Vocational education

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must prepare graduates who are easily absorbed by the industrial world as well as the business world, especially for problem-solving; one of the solutions is to improve the learning model. Project-based learning models can develop soft skills, acquire knowledge to critically solve problems, and foster creative thinking skills.

Module development is one of the projects in research that supports learning to become more efficient (Rati et al., 2017; Almulla, 2020). According to Darling-Hammond et al. (2020), the advantage of this characteristic is that it can assist and design learners to discover learning outcomes, train them to be responsible for managing information in a project. The development of modules also aims to improve learning outcomes more effectively compared to before. Project-based learning positively influences students' learning outcomes in cognitive, psychomotor, and affective domains (Susanti et al., 2019; Zhang & Ma, 2023). Observations in one department (Electrical Engineering) found that teaching is mostly theoretical explanations using lecture methods and additional PowerPoint media commonly used by instructors, along with English-language online books provided to students. In this case, it is clear that students are reluctant to read these books due to language limitations, resulting in suboptimal learning and insufficient learning outcomes.

Based on the learning outcomes obtained from the Electrical Circuit Midterm Exam, the average score of 46 students was 30.4 out of 46. The use of foreign language reading materials reduces interest in reading, necessitating simpler and more practical reading materials such as modules tailored to students' needs. Module development is needed in this course to facilitate more independent learning for students. Modules should be tailored to students' needs. According to Sadler et al. (2023) and Asri et al. (2022), modules are systematically designed teaching materials based on a specific curriculum and packaged in the smallest learning units, allowing independent learning within a specific timeframe. They contain a set of planned learning experiences designed to help learners master specific learning objectives.

Project-based learning modules motivate students to solve problems in the Electrical Circuit course (Hamid et al., 2020; Pawar et al., 2020). These modules are self-learning materials with easily understandable language for students. It is hoped that project-based development models will enhance student engagement compared to conventional models. This model encourages students to think more actively and understand the material by investigating real-world problems, resulting in a deeper and more meaningful understanding of what they are learning.

Method

This research is an R&D (research and development) study. Guo et al. (2018) and Lee et al. (2017) explains that R&D is a research method used to create specific products and test their effectiveness. This is consistent with Gay et al. as cited in Dwivedi et al. (2023) and Montenegro-Rueda et al. (2023) who explain that in the education sector, the essence of development research is not to design or conduct theoretical studies, but to develop effective products used in educational institutions. The research was conducted in the Semester 1 D4 Electrical Engineering Program, Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang in the odd semester of the academic year 2023/2024. The subjects of this research are students of the D4 Electrical Engineering Program, Faculty of Engineering, UNP in the July-December 2023 semester. In the validation stage, there are 4 lecturers who will validate the development of the learning module. Some aspects of validation conducted include validation of content, media, and language of the learning module.

The data collection techniques used in this research include observation, interviews, questionnaires, documentation, and posttest and pretest questions. Observation is conducted through observing student learning without using the learning module. Next, lecturers and assistant lecturers are interviewed to understand the learning process. Questionnaire data collection technique is carried out during media expert validation and material expert validation of the learning module. Documentation is conducted when the module is tested with students. Posttest and pretest questions are provided to determine the effectiveness level of the learning module in student learning outcomes. The instruments used for data collection include validation questionnaire sheets for media and material experts, response questionnaire sheets for lecturers and students, and posttest and pretest sheets.

The analysis technique for assessing the feasibility of the learning module uses a Likert scale. Respondent answers are scored on a scale where very good is assigned a weight of 5 points, good is assigned 4 points, fair is assigned 3 points, poor is assigned 2 points, and very poor is assigned 1 point. Practicality is a stage of implementation and use of the module by students and lecturers in learning using the revised module based on validator assessment. It is considered practical if the responses given to the module are judged to be good according to practical criteria standards. Practicality analysis is conducted using percentage values (%).

$$\text{Practicality value} = \frac{\text{Total score obtained}}{\text{Maximum total score}} \times 100\% \quad (1)$$

Effectiveness testing is carried out by comparing conditions before and after using the learning module. Normality testing is conducted to assess the distribution of data for a variable, determining whether the data distribution is normal or not. The technique used is the Kolmogorov-Smirnov normality test, and the developed module then undergoes the Paired T-test analysis technique using SPSS application.

Result and Discussion

The results of the project-based module development research in the Electric Circuit course are as follows.

Validity Test

Validity analysis by experts using Aiken's formula can be seen in Table 1.

Table 1. Material Validity Validation by 2 Experts

Item	Evaluator		S1	S2	Σs	n(c-1)	V	Remarks
	I	II						
Item 1-16	71	69	55	53	108	128	0.84	Valid

From the statements in each item, both material experts stated that the electric circuit module received a score of 0.84, which is declared valid and suitable in

terms of material. Items 1 to 16 were considered valid and suitable for use.

Table 2. Media Validity Validation by 2 Experts

Item	Evaluator		S1	S2	Σs	n(c-1)	V	Remarks
	I	II						
Item 1-30	128	131	98	101	199	240	0.83	valid

The questionnaire items 1 to 30, evaluated by media experts, showed that the module received a score of 0.83, declared valid in terms of media.

Practicality Test

The practicality test is based on responses from relevant lecturers and students.

Table 3. Lecturers Respondent

Respondent	Statement Items	Total Score	Max Score	Value (%)	Remarks
Lecturers	Items 1 - 10	39	50	78	Practical

The response of Electric Circuit course lecturers to the Electric Circuit learning module was positive, with a practicality level of 78%, making the module practical

for use by students in the odd semester of July-December 2023.

Table 4. Student Responses

Respondent	Statement Items	Total Score	Max Score	Value (%)	Remarks
1 - 30	Items 1 - 10	1201	1500	80	Practical

The questionnaire distributed to 30 students enrolled in the Electric Circuit course, with 10 statements, indicates that the module received a score of 80%. This 80% score indicates that the module they used is practical for learning Electric Circuit.

Effectiveness

The effectiveness of the developed Electric Circuit module is evaluated based on the comparison of pretest and posttest results of students using the module. As seen in the table below, the normality test analysis using Kolmogorov-Smirnov with SPSS Ver. 26 at a significance level of 5% shows that the data results are normally distributed in the comparison of pretest and posttest results.

Table 5. Normality Test

Test	P-Value	Description
Normality Test	0.20	Normal

The paired sample T-test is used to compare two means from two paired samples with data that has been normally distributed. The paired samples are derived from the same subjects and taken in different situations, such as before and after using the learning module.

Table 6. T-test

Test	P-Value
T-test	0.00

In the table above, the result of the T-test analysis shows a significance level of $0.000 < 0.05$, indicating a

significant difference between the pretest and posttest. This indicates an influence on the difference in treatment given to the research subjects, namely the use of project-based learning modules in the Electric Circuit course. The validity test conducted by 4 experts, consisting of 2 content experts and 2 media experts, was analyzed, and the results of the analysis for the content validity test by 2 content experts concluded that the Electric Circuit learning module is valid for use with some suggestions for improvement, obtaining a score of 0.84. The media validity test by 2 media experts concluded that the Electric Circuit learning module is valid for use with some suggestions for improvement, and received a score of 0.83 from the media experts. The conclusion drawn from the content and media validity tests on the development of the project-based module in the Electric Circuit course indicates that it is valid for use with some suggestions for improvement.

To obtain a good product, the practicality of the product for use in learning the course should also be considered. This practicality test looks at responses from the respective lecturers and students involved in the learning activities (Murphy et al., 2023; Wang & Tahir, 2020; Grassini, 2023). The response from the course lecturers to the practicality test using questionnaire statements yielded a response rate of 78%, indicating that the module used for learning the Electric Circuit course is practical. Meanwhile, the response from the 30 students in the class yielded an 80% response rate, indicating that the module used for their learning is practical, providing assistance and additional references for the students in their learning process (Fabrizz et al., 2021; Tang & Hew, 2022; Zheng et al., 2021).

The normality test is an evaluation of the comparison of results before and after conducting treatment using the module in learning (Kintu et al., 2017; Smiderle et al., 2020). The conditions are taken to determine learning outcomes using pretest and posttest results. The analysis using Kolmogorov-Smirnov with the assistance of SPSS Ver. 26 software at a significance level of 5% showed that the data results are normally distributed, which, based on the prerequisite analysis in the effectiveness test with Paired T-test, obtained a normality test result with a significance value of $0.200 > 0.05$.

Paired T Test is a statistical test used to determine the effectiveness of a module by comparing the means of two paired samples, originating from the same subjects but taken in different situations and conditions before and after receiving the module treatment. The analysis conducted to observe the Paired T Test results obtained a significance level of $0.000 < 0.05$, indicating a significant difference between the pretest and posttest results. It is concluded from this effectiveness test that there is an influence of the difference in results before

and after receiving the treatment of using the Project-Based Module Development in the Electric Circuit course.

The stages of this research are in accordance with the stages of development research based on the 4D development, namely:

Definition Stage (Define)

The definition stage is useful for determining and defining the needs within the learning process and collecting various information related to the product to be developed. This stage is divided into several steps: Initial Analysis (Front-end Analysis): Initial analysis is conducted to identify the basic problems in the development of the learning module. Currently, many students have not achieved optimal learning outcomes (Erikson & Erikson, 2019). To create maximum results, students are required to be able to learn more. The development of this module aims for students to achieve maximum learning outcomes and for students to be able to think critically, independently, and solve their own problems with tested modules; Concept Analysis: Concept analysis of student characteristics is an examination based on their knowledge and skills (Tsimane & Downing, 2020; Valloze, 2009). This analysis also includes the learning attitudes of each student participating in the Electric Circuit lectures. The analysis results of student characteristics who have the ability to think critically and creatively and can solve problems depict the objectives of developing the learning module (Raslan, 2023; O'Reilly et al., 2022; Stehle & Peters-Burton, 2019).

Task Analysis: Material analysis determines the learning materials adapted so that students can achieve the learning objectives based on the learning module to be used in the course; Learning Objectives Analysis (Specifying Instructional Objectives): Learning objective analysis is carried out to determine learning achievement indicators based on material analysis and syllabus analysis. By writing learning objectives, researchers can determine what studies will be presented in the learning module and determine how much the learning objectives are achieved.

Design Stage

The development procedure in the design stage involves planning the development of the learning module, which includes the following steps (Khalil & Elkhider, 2016): drafting specific learning objectives; designing learning materials based on the analysis of learning objectives; preparing tests as learning evaluations with the learning module used.

Development Stage

The development stage is the realization activity of the learning module that has been determined in the design stage. Some steps taken in the development stage include: Expert Validation (expert appraisal); Expert validation is performed by experts who assess the validity of the learning module. Validity assessment by content, media, and language experts is done using questionnaires (Masuwai et al., 2024; (Zhang & Aryadoust, 2022; Chiwaridzo et al., 2017). The assessment, suggestions, and input from the validators on the learning module are then periodically revised by the researcher to obtain a draft of the learning module ready for testing on research subjects; Product Testing (development testing): After expert validation, limited field testing is conducted to determine the results of implementing the learning module in the classroom, such as measuring student learning outcomes. The results obtained from this stage are revised learning modules.

Dissemination Stage

After limited product testing and revision of the learning module, the next stage is dissemination. The purpose of this stage is to disseminate the learning module (Afrizon et al., 2019; Dewi et al., 2019; Gil Jiménez et al., 2023). In this study, only limited dissemination is carried out by distributing the final product in a limited manner to Electric Circuit lectures in the D4 Electrical Engineering Program, Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang. In this stage, after the product is disseminated and used in subsequent learning processes, learning outcomes are measured through pretest-posttest experiments.

The research and development implementation are conducted with two types of data: quantitative data and qualitative data. Quantitative data are countable data in numerical form. Quantitative data in this research include validation assessment scores of the learning module by experts, practicality scores of the learning module from the responses of lecturers and students, and the effectiveness data of the learning module application through a one-group pretest-posttest design study (Utaminingsih et al., 2022). Qualitative data, on the other hand, are non-countable data in the form of sentences or explanations. Qualitative data in this research consist of critiques and suggestions from experts regarding the developed learning module.

Conclusion

The content validity score of 0.84 indicates that the module is valid, and the media validity score of 0.83

indicates that the module is valid and ready for use. The response of the course lecturers to the practicality test, using questionnaire statements, obtained a response rate of 78%, indicating that the module used for teaching the Electric Circuit course is practical. Meanwhile, the response from the 30 students in the class yielded an 80% response rate, indicating that the module used for their learning is practical and provides assistance and additional references for the students in their learning process. The module developed in this study, through data analysis, obtained a significance level of $0.000 < 0.05$, indicating a significant difference between the pretest and posttest results. It is concluded from this effectiveness test that there is an influence of the difference in results before and after receiving the treatment of using the Project-Based Module Development in the Electric Circuit course.

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Author Contributions

Conceptualization; J. D. R. S., A., R. M., R. E. W.: methodology; J. D. R. S., validation; A.: formal analysis.; R. M.: investigation.; R. E. W resources; J. D. R. S: data curation: A.: writing—original; R. M: draft preparation; R. E. W: writing—review and editing; J. D. R. S; visualization: A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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