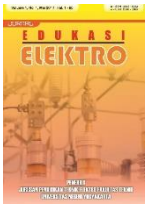
Volume 07, No. 02, November 2023, pages 169 - 180

JEE

Jurnal Edukasi Elektro

https://journal.uny.ac.id/index.php/jee



E-MODULE DEVELOPMENT IN ELECTRICAL CIRCUITS COURSES BASED ON PROJECT LEARNING

I Gede Budi Mahendra[1](✉), Janne Deivy Ticoh[1], Djami Olii[1], Usman Nursusanto[2]

[1] Universitas Negeri Manado, Tondano, Indonesia

[2] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

igedebudimahendra@unima.ac.id

Abstract— The lack of maximum learning motivation has a direct impact on student lecture outcomes. The provision of teaching modules needs to be adjusted to ICT developments in order to provide more meaningful lectures. This development research aims to produce e-modules based on project learning (PjBL) in electrical circuit courses that are valid, practical and have a positive impact on student learning outcomes. This research is development research using the ADDIE model with five stages: analysis, design, development, implementation, and evaluation. The subjects of this study consisted of 2 material, media, language experts, 38 semester 2 students, and 2 course lecturers. Data was collected through questionnaires and tests. The research instruments included validity and practicality questionnaire sheets, as well as tests of electrical circuit lecture results. The results of the research show that the E-module developed has a validity level from media experts of 90.00% with a Very Valid classification, a validity level from language experts of 86.00% with a Very Valid classification, and a validity level from material experts of 92.00 % with Very Valid classification. This PjBL-based e-module also has a level of practicality in terms of the student aspect of 88.14%, including in the "Very Practical" category, a level of practicality in terms of the lecturer's aspect of 82.60%, including in the "Very Practical" category and is effective in improving results Electric circuit lecture.

Keywords: E-Module Development, Project based learning, electrical circuits, ADDIE

Article submitted August 31, 2023. Resubmitted September 21, 2023. Final acceptance October 16, 2023.

1 Background

21st century learning refers to learning approaches and methods that are relevant and in accordance with the demands and developments of the 21st century. Various challenges and significant changes occur due to the impact of technology, globalization and rapid social transformation. The educational paradigm in the 21st century demands that educational institutions, including higher education, guarantee that students have high-level thinking abilities which imply reasoning, systematic, critical and creative abilities in solving problems[1]. This aims to enable students to be able to answer the challenges of education in the future. Skills in the 21st century are 4C (Critical thinking, Collaborative, Communicative, and Creative) and integrating HOTS (High Order Thinking Skill)[2]. In responding to the challenges of 21st century education, students are required to master learning both in terms of the ability to use ICT and in terms of high-level thinking abilities. Indonesia is ranked 155th out of 139 countries with an index of 0.202. From this research, it shows that the level of creativity in Indonesia is classified as unsatisfactory. The problem of the difficulty of cultivating student creativity is due to the fact that education in Indonesia is currently more result-

oriented in the nature of repetition, memorization and searching for the correct answer to the questions given so that students tend to get bored quickly [3]. This happens because students are lacking in carrying out learning activities that train creative thinking [4] [2]. Student creativity is still low as evidenced by the test results for each indicator of creative thinking that is incomplete.

Creative thinking is the ability to build ideas or solutions to solve problems and create new things from before. Creative thinking has four indicators, namely fluent thinking (fluency), flexible thinking (flexibility), original thinking (originality), and detailed thinking (elaboration) [5]. One effort to train creative thinking skills is to apply learning that involves students in real life. One learning model that can be applied is Project based learning (PjBL). The PjBL learning model can improve students' creative thinking. Including several project-based activities that can improve students' creative thinking abilities. Apart from that, through PjBL learning, it turns out that it is able to facilitate students to face the demands of 21st century skills. This can be seen from the increase in student creativity in terms of fluent, flexible, original thinking skills, elaboration and evaluation skills through PjBL learning so that students become better prepared to face the demands of the 21st century as stated in [6].

PjBL learning is a learning model that is student-centred, long-term, focuses on the problem to be solved and provides a meaningful and real learning experience for students. PjBL learning is used to solve problems in everyday life by producing products from given projects. Project selection is carried out by presenting problems or problematic phenomena that occur in society. Based on this description, the student's thinking process starts from observation until the student can actively convey the results of the analysis based on experience and initial knowledge, showing that this stage can improve critical thinking skills in solving problems in everyday life [7]. The stages of the PjBL learning model begin by focusing students on questions or problems that will determine the project topic, designing project completion steps, preparing a project implementation schedule, completing the project with lecturer guidance, preparing reports, publishing project results, and evaluating project processes and results. PjBL learning is carried out by linking learning material with real conditions in the environment around students. In the lecture process, of course, learning tools are needed that support lecture activities so that the lecturer's objectives can be conveyed well [8].

Looking at the conditions in the electrical engineering education department at Manado State University, especially in the electrical circuit lectures, it can be seen that learning support facilities such as the internet are available, but unfortunately, students use the internet more for self-existence than for studying. The lecturers do not yet have textbooks as a guide, resulting in only internet-based learning which is outlined in short material with the help of learning media in the form of power points. This problem has an impact on students' lack of knowledge. The lack of student knowledge causes student competence to be less than optimal, thus potentially reducing the quality of education [9]. Apart from the fact that the teaching materials provided by lecturers are not updated, it was found that supporting reference books regarding electrical circuits courses in the campus library are relatively rare, so students tend to look for their own learning resources which are dominated by the internet so that the information students get is not optimal and meet the expected learning outcomes [10].

Referring to the results of initial observations and interviews from students of the Electrical Engineering Education study program, efforts are needed to overcome these problems, by developing innovative, creative and interactive learning resources to be able to direct students to meaningful learning and improve learning outcomes. The solution to this problem is the development of electronic teaching modules or E-Modules. E-Modules are teaching materials that can help students study subject matter independently which uses ICT-based media [10] [3]. By using e-modules, it is hoped that students can learn anytime and anywhere, using the right sources. Lecturers can still control students' completeness in learning. E-modules are learning resources that are compiled from various materials in the courses studied, and there are questions to train students' abilities that can be accessed digitally anytime and anywhere, supported by adequate tools, and do not make things difficult for students. Using e-modules can increase the attractiveness and make it easier for students to understand and accept the material and with e-modules lecturers can focus students in learning activities and attract students' attention and interest. [11].

E-Modules are very important to develop in the learning process to facilitate students in independent study or self-study, both conventional and face-to-face. E-learning modules need to be developed because they can help students achieve a level of individual learning completeness. Educators can direct and see the achievement of learning objectives using the guidebook from the learning module [10]. Students can choose to continue with the next learning activity even though they have not reached the level of completion in the previous learning activity [12]. Likewise, students can choose to complete a learning activity and then continue on to the next learning activity. The lecturer's task is to see the extent of students' abilities in completing learning activities.

The e-module developed is focused on project creation activities to train student creativity by involving them in more complex problems in the environment around students. Project activities in this e-module are linked to indicators of creative thinking through several related activities in real life. The e-module developed is packaged using software that can create student understanding visually and can attract students' interest in understanding the material so that students will enjoy learning with a different impression [10]. Project activities and questions to practice creative thinking skills are packaged into several e-module features to make studying easier for students. Based on this, this development research aims to produce e-modules based on project-based learning (PjBL) in electrical circuit courses that are theoretically and empirically valid and practical. Apart from that, e-modules based on project-based learning (PjBL) are expected to have a positive impact on student competence.

2 Literature Review

2.1 E-Module Development

E-Module is a collection of subject matter used by students for independent study, which is studied gradually and thoroughly, arranged systematically, equipped with assignments, exercises or evaluation materials, as well as other supporting materials to support the learning process in certain subjects [10] [13]. E-Module is a modification of conventional modules by combining the use of information technology through activities, so that existing modules can be more interesting and interactive because with e-modules we can add multimedia facilities (images, animations, audio and video) in it [11]. E-Modules can also add interactive test or evaluation facilities so that students can interact more with their learning resources. This E-Module development has the advantage of e-Modules compared to conventional modules where E-Modules are more attractive, because they can be equipped with multimedia facilities (images, animation, audio and video) [14]. It is more interactive because students can self-evaluate a competency and at the same time take follow-up actions after knowing the results of the evaluation, they carried out independently.

2.2 Project Based Learning

The application of the Project Based Learning (PjBL) model is one of the solutions needed to overcome problems in the learning process. PjBL is a learning model that provides educators with the opportunity to manage learning in the classroom by involving project work [6]. The final result of project work is a project which is not necessarily in the form of material, but can be in the form of a presentation, drama and other models which are presented in public and evaluated for quality [15].

The PjBL learning model is able to improve collaboration skills and provide free space for students to build knowledge and develop their skills. The PjBL learning model makes students active and improves learning outcomes in the effective, cognitive and psychomotor domains so that it is in line with the demands of facing the 21st century [16] [8]. In building student competency, the focus is not only on skill competency but also on student assessment which includes aspects of imitation, manipulation, articulation, and naturalization.

The PjBL learning model facilitates students to investigate, solve problems, be student centered, and produce products in the form of project results. There are many learning methods used by teachers, teaching staff and lecturers in conveying or transferring knowledge. The use of the PjBL model can make students act as active and creative students and make learning andagogic, able to complete a project given by the student [6].

2.3 Electrical Circuit Courses

Electrical circuits are a mandatory subject taken by students of the electrical engineering education department at Manado State University. This course has code 5133202KM-1 where this course uses a project-based learning approach. After attending lectures, students who take this course are expected to be able to understand the basics of electrical circuits, the basic laws of electrical circuits, apply these basic concepts/laws in circuit analysis and calculations and be able to prove the truth of basic electrical circuit theory, circuit analysis and characteristics correctly.

3 Method

3.1 Types of research

The type of research used to solve the problem is development research (R&D) with a design using the ADDIE model. The ADDIE model is a development research design which consists of five steps, namely analysis, design, development, implementation and evaluation. E-Module development in electrical circuits courses based on project learning is structured with several procedures according to the steps of the ADDIE model. The first step is the analysis stage. At the analysis stage, a needs analysis was carried out for Project Based Learning-based E-Modules for the electrical circuit course. Further analysis consists of analysis of the curriculum used, namely the Independent Learning Curriculum, the characteristics of second semester students class of 2022 majoring in electrical engineering education who already have gadgets or computers so that they can be given E-Modules in lecture activities.

The next step is the design stage. At the design stage, the E-Module is designed by arranging the design appearance, selecting Graduate Learning Achievements and Course Learning Achievements as well as compiling the materials that will be included in the e-module. Then proceed with the development stage, where at this development stage through various steps such as testing the validity of the instrument. At the implementation stage, a test of the effectiveness of the E-module was carried out by second semester students of the class of 2022 in the electrical engineering education department in the electrical circuits lecture. The final stage is the evaluation stage. At the evaluation stage, an evaluation of the e-module electrical circuits has been developed and evaluation of the results before using the product and after using the e-module product [17]. The design of the research conducted can be seen in Figure 1.

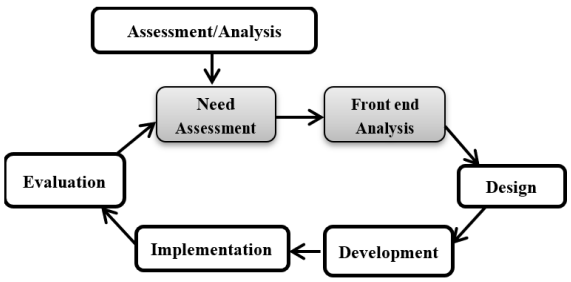


Fig. 1. The ADDIE instructional design cycle

3.2 Subject and object of research

The subjects of this electrical circuit E-module development research consisted of 2 learning media experts, 2 material experts in the field of electrical circuits, 2 language experts, 38 students and 2 lecturers in the electrical engineering education department at Manado State University. This is aimed at measuring the effectiveness of using the PjBL-based E-Module for electrical circuits in increasing student competency. The object of this research is the PjBL-based electric circuit e-module that has been developed.

3.3 Data collection techniques

The data collection technique carried out in this research was using questionnaires and learning outcomes tests. The instruments used consisted of an E-module validation questionnaire sheet for material experts, language experts and media experts, a practicality test sheet for use by students and lecturers, as well as a test of lecture results on electrical circuits. The lecture learning outcomes test includes 20 questions with the cognitive dimension (C4) with the Higher Order Thinking Skill (HOTS) question type. The validity and practicality of the questionnaire questionnaire sheet has been tested for validity and reliability before being used in data collection.

3.4 Data analysis technique

The research data that has been collected was analyzed using descriptive qualitative and descriptive quantitative analysis methods. This qualitative descriptive analysis is used to determine the design of PjBL-based electrical circuit E-modules. Qualitative descriptive analysis techniques are used to explain and analyze data expressed in sentences and words. Meanwhile, the quantitative descriptive analysis method in this E-Module consists of validity tests by media experts, material experts, language experts, practicality tests and effectiveness tests. The conversion guide for evaluating the validity and practicality of the E-module is presented in Table 1 and Table 2.

Table 1. Conversion of e-module validity scale 5 results

Level of Achievement	Qualification	Description
85% - 100%	Very Valid	Worth using without revision
70% - 85%	Valid	Suitable for use with necessary revisions
55% - 70%	Not enough	Not yet suitable for use and there are still many revisions
0 % - 50%	Bad	Not suitable for use and must be completely revised

Table 2. Conversion of scale 5 practicality of e-module results

No.	Persentase (%)	Category
1	0 - 20	Impractical
2	21 - 40	Less Practical
3	41 - 60	Pretty Practical
4	61 - 80	Practical

Analysis of the value of the impact or effectiveness of using the E-module can be seen and determined through the following hypothesis. Null hypothesis (Ho) There is no increase in the average results of electrical circuit lectures for students in the second semester of electrical engineering education using the PjBL-based E-Module for electrical circuits. Alternative hypothesis (Hα): There is an increase in the average output of electrical circuit lectures for semester 2 students of electrical engineering education using PjBL-based electrical circuit E-Modules. μ is the average value of the results of the lecture on electrical circuits in semester 2 of electrical engineering education students who are given the E-Module during lectures on Electrical Circuits. While μ0 is the hypothesized value. Before the hypothesis testing is carried out, the results of the lecture on electrical circuits for students in the second semester of electrical engineering education are first tested through a normality test. The normality test is carried out with the help of IBM SPSS for windows.

4 Results and Discussion

4.1 Result

The development of the PjBL-based electric circuit E-module is structured in several procedural stages according to the ADDIE development model which consists of 5 activity stages.

1) Analysis

At the analysis stage, a needs analysis was carried out for the e-module for the electrical circuits course in the electrical engineering education department, Manado State University. The next analysis that was carried out was an analysis of the curriculum used, namely the Freedom to Learn Curriculum, the characteristics of semester 2 students class of 2022 in the electrical engineering education department who already have gadgets or computers so that they can be given E-Modules in lecture activities. In the electrical engineering education department, especially in electrical circuit lectures, it is known that supporting lecturers do not have textbooks as a guide, resulting in only internet-based learning which is outlined in short material with the help of learning media in the form of power point. Therefore, lecturers need other teaching modules to support innovative electrical circuit lectures. In addition, students need technology-based teaching materials because they tend to prefer learning with internet-based media.

Analyzing student characteristics is also important because it influences the success of the e-module being developed. Activities Analyzing student characteristics are carried out for understand the characteristics of students such as thinking abilities, habits or ways of learning, ability to access technology and information, as well as economic condition factors. Analysis that is also carried out is the lecture environment. Analyzing the lecture environment aims to find out what the student's lecture environment is like, especially in the electrical engineering education department at Manado State University. The lecture environment analyzed includes the comfort of the lecture room, the completeness of the lecture facilities, and the conditions of interaction between students and lecturers.

2) Design

The second stage of ADDIE is the design stage. At this design stage, E-Module design activities are carried out by preparing the cover display design. Activities carried out at this stage include choosing the form of delivering the e-module message, creating lecture instructional strategies, designing assessment and evaluation instruments, mapping e-module elements starting from color, layout and appropriate illustration images. At the design stage, activities are also carried out to compile interactive e-module systematics such as designing flowcharts, media navigation structures and e-module storyboards. Specifically, the preparation of lecture instructional strategy design includes activities for selecting graduate learning outcomes and course learning outcomes, determining sub-course learning outcomes, as well as compiling materials that will be included in e-modules.

3) Development

Then proceed to the third stage of ADDIE, namely the development stage through various steps including collecting pre-designed e-module elements, media creation activities, and conducting e-module validity tests for media experts, material experts and language experts. This PjBL-based E-module product was developed using the help of Microsoft Word and Flipbook software to produce a module product that can be accessed electronically/digitally in the form of a PDF. The products that have been developed can then be used through access from a variety of electronic devices (devices), including smartphones, iPads/tablets, computers, and laptops. E - This PjBL-based electrical circuit module is structured with 5 chapters of material in electrical circuit lectures, namely Electric

Circuit Concepts, Electrical Circuit Elements, Basic Laws of Electrical Circuits, Complex Impedance, and Circuit Analysis Methods. This electrical circuit e-module consists of 81 pages starting from the front cover, contents to the cover. The results of the E-Module development in electrical circuits courses based on project learning can be presented in Figure 2.

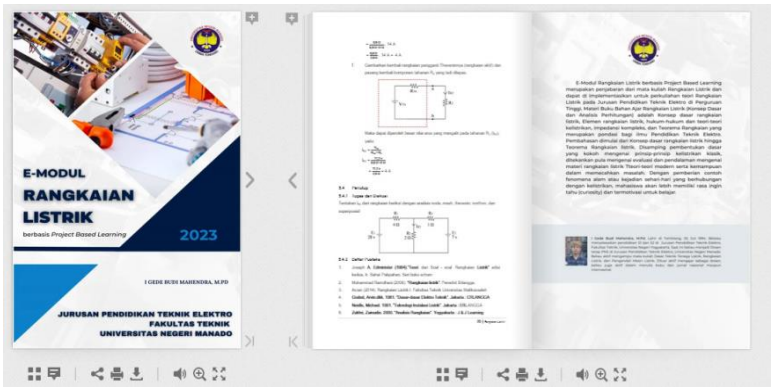


Fig. 2. View of the front cover and cover of the e-module

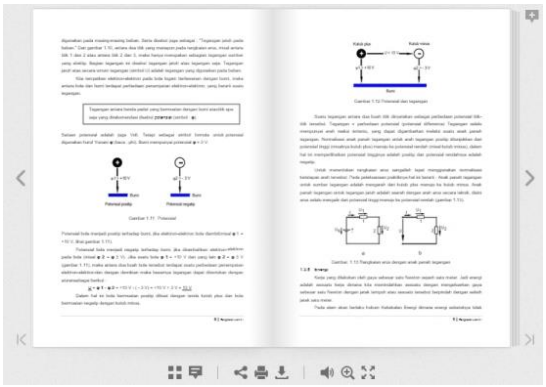


Fig. 3. Sample of e-module content display

E-Module development in electrical circuits courses based on project learning has been completed through the development stage, where the product results compiled are then tested for feasibility in terms of media, material and language through expert validity tests. The validity test results can be presented in full in Table 3.

Table 3. E-module validity test results

Aspect	Percentage of Feasibility/Validity	Qualification
Material Expert	92,00%	Very Valid
Media Expert	90,00%	Very Valid
Linguist	86,00%	Very Valid

Based on Table 3 it states that the validity value for media experts is 90.00%, the validity value for material experts is 92.00% and the validity value for linguists is 86.00%. Based on the validity percentage conversion, it can be stated that the validity of the PjBL-based electrical circuit E-module when viewed from the validity of material experts, media experts, and linguists is in the "Very Valid" category, which means that this E-module product is suitable for use in lectures on electrical circuits in the Department of Electrical Engineering Education, Manado State University.

4) Implementation

E-module products that have been validated by material experts, media experts and language experts are then carried out in the product implementation stage. At the implementation stage, the lecture environment was organized and the practicality of using the E-module electrical circuit was tested. The organization of the lecture environment is carried out with the aim of ensuring that the lecture rooms and required facilities are available before testing the practicality of using e-modules. Furthermore, the practicality of the E-module developed was assessed by involving lecturers in the Department of Electrical Engineering Education, namely 2 lecturers who taught the course and 38 students in semester 2. The results of the practicality analysis of students and lecturers who taught the course can be seen in Table 4 below.

Table 4. E-module practicality test results

Aspect	Practical Percentage	Qualification
Student practicality	88,14%	Very Practical
Lecturer practicality	82,60%	Very Practical

Based on Table 4 above, it shows that the results of the practicality analysis of the E-module for electrical circuits in terms of the student aspect are included in the "Very Practical" category with a percentage of 88.14%. Meanwhile, the results of the practicality analysis viewed from the lecturer's aspect of the E-module electrical circuit being developed are included in the "Very Practical" category, namely with a percentage of 82.60%. In accordance with the practicality percentage conversion guidelines, it can be stated that this PjBL-based electric circuit E-module is in the "Very Practical" category. This proves that the E-Module that has been developed is very practical to use for lectures on electrical circuits in the Department of Electrical Engineering Education, Manado State University.

5) Evaluation

At the evaluation stage, an assessment of the E-Module electrical circuit that has been developed is carried out. The research results obtained explain the results of the development of the E-module which was assessed in terms of validity, practicality and impact or effectiveness of its use in lectures on electrical circuits. The data obtained through the post-test was then analyzed descriptively to obtain the average value of the electrical circuit lecture results. The average analysis results are listed in Table 5.

Table 5. Descriptive Analysis Results

Lecture Results	***Mean***	77.25
	Minimum Value	55
	Maximum Value	90

Based on Table 5, it shows that the average value obtained when compared with the hypothesized minimum completeness value is $\mu = 77.25 \geq \mu 0 = 70$, meaning that Hα is accepted, namely "There is an increase in the average results of lectures on electrical circuits for semester 2 students using PjBL Based E-Module" with an increase of 7.25. Before the t-test for one sample was carried out, a prerequisite analysis test was first carried out, namely the normality test. Data can be declared to have been normally distributed if the Kolmogorov-Smirnov significance value ≥ 0.05 then H0 is accepted (data normally distributed), conversely if a significance value is obtained ≤ 0.05 then H0 is not accepted (data not normally distributed). The normality test uses Kolmogorov-Smirnov, namely 0.0816. This means that the data has a normal distribution and can be classified as having met the prerequisite tests in the T-test. The results of the test analysis using the One Sample T-test can be presented in Table 6.

Table 6. Descriptive Analysis Results

One-Sample Test						
	Test Value = 70					
	t	df	Sig. (2-tailed)	Mean difference	95% Confidence Interval ofthe Difference	
					Lower	Upper
Lecture Results	8.172	31	0.000	7.25	8.80	14.20

Based on the results of the t-test analysis for one sample, the value of tcount is 8,172 > ttable 2.03, which means that tcount is greater than ttable so that according to the hypothesis testing criteria, Ha is acceptable and based on the sig value. 2-tailed 0.00 < 0.05 significance level. Therefore, it can be stated that the E-Module development in electrical circuits courses based on project learning has a positive or effective impact on improving the results of lectures on electrical circuit courses in the electrical engineering education department, Manado State University.

4.2 Discussion

Based on the overall results, it can be interpreted that the PjBL-based electrical circuit E-module developed is valid, practical and effective in improving the results of semester 2 students' lectures in the electrical circuit course. The findings are proven through validity analysis, practicality analysis and effectiveness analysis. In the effectiveness test, the result was that the E-module product developed could improve learning outcomes with an increase of 7.25. This very valid level of material validity is supported by the suitability of the E-module which was designed with lecture objectives and the scope of the material, namely Electrical Circuit Concepts, Electrical Circuit Elements, Basic Laws of Electrical Circuits, Complex Impedance, and Circuit Analysis Methods. Apart from conformity with the demands of the independent learning curriculum, material that is in accordance with Graduate Learning Achievements, Course Learning Achievements and course objectives certainly influences the suitability of the material content in the E-module which is proven to be very valid. The sequence of material discussed also helps present the E-module properly so that it is easy to understand. The level of suitability (validity) of a teaching material such as a teaching module can be seen from the sub-aspects/indicators of Course Learning Achievements, materials and evaluation. Apart from that, the material in the electronic module is packaged with various illustrative images which are useful for making it easier for students to understand the lecture material.

The second finding is the validity of the percentage of media experts and linguists in the Very Valid category. This is attributable to the use of communicative language in the E-module. The language used in preparing the E-module material is in accordance with student characteristics. Thus, students will find it easier to use the E-module. Apart from that, the compiled E-module is supported by a variety of illustrative images that are appropriate to the material. This compiled e-module is practically used for lecturers in charge of courses and students. This is due to several supporting factors such as the features, attractiveness and benefits provided by this PjBL-based electric circuit E-module [18]. A good E-module can be seen if it is arranged in a structured format with complete supporting features, examples of material features, evaluation, reference list, and others. The use of standard language, detailed and systematic material, illustrative images that are relevant to the material, attractive evaluation features and an appropriate reference list will provide an excellent category for the e-module being developed as stated in [19]. This electrical circuit e-module is structured in an efficient language according to the EYD spelling and is understood by students based on its characteristics. Because the language used in the material can also influence the level of students' understanding and mastery of the material being studied [20]. The regularity of sentence structure, spacing and flow of material also contributes to the practicality of the E-module being developed. A teaching material such as an E-module must be equipped with 6 quality elements, namely consistency, format, attractiveness, organization, font form, and use of white space. The format used must pay attention to the layout and typing format. All e-module components are included in the storyboard, including the cover and backdrop, the type of letters and font size used, the resources arranged, assignments and quizzes included in the e-module. Organization E-modules are designed to organize content, include images, and also include quizzes and videos. preparing

and placing texts, pictures and illustrations in such a way that the information is easy to understand and increases students' interest in learning so that the E-module is effective in increasing students' interest in learning and mastery of the material. [21] [22].

The effectiveness of the PjBL-based E-module for electrical circuits shows that the use of this E-module has a positive impact on the results of lectures on electrical circuits. This is because the PjBL-based electrical circuit E-module is prepared using PjBL syntax which trains student cooperation and their own knowledge in completing assignments and evaluation questions. This PjBL-based electrical circuit e-module was developed by integrating PjBL syntax into the module activity components. This PjBL-based electrical circuit e-module has been proven to be able to improve student learning outcomes by integrating PjBL syntax. The first PjBL model syntax is basic questions, the second PjBL model syntax is project design, the third PjBL model syntax is project schedule structure, the fourth PjBL model syntax is monitoring project progress, the fifth PjBL model syntax is project assessment, PjBL model syntax the sixth is experience evaluation. From the results of this evaluation, lecturers and students can carry out follow-up actions for activities that will be carried out afterwards [23]. There are several advantages to the PjBL learning model, such as PjBL can increase student learning motivation, PjBL increases students' ability to learn cooperatively and collaboratively, and PjBL can also increase student creativity [2] [8].

Based on the results and discussion above, it can be stated that the e-module developed has produced a PjBL-based electrical circuit E-module product which is very valid, practical and effective for improving the results of the second semester students' electrical circuit lectures majoring in electrical engineering education, Manado State University.. The E-module developed has various advantages that are able to support lectures on electrical circuits. These advantages include training students' ability to collaborate, be independent, disciplined and communicative through project-based learning conceptualized in E-modules, providing high opportunities for students to be brave in conveying their participation in learning, containing attractive designs with the support of relevant images and illustrations, can be used easily for beginners because the product is user friendly, the language chosen in the E-module is adjusted to the student's characteristics. Digital-based media forms make it easy to access media anywhere and anytime [24]. Apart from that, the use of digital-based media can provide a new atmosphere for students, thereby increasing student interest and motivation in learning. This has implications for course lecturers who act as educators to prepare more innovative learning, especially by utilizing digital or electronic modules. Apart from being more practical and easily accessible anywhere, this research has implications for students in improving their learning outcomes in series courses. The PjBL-based E-module electric circuit development product for 2nd semester students contributes to providing and increasing types of digital-based innovative media and can be used by students in the electrical engineering education department.

6 Conclusion

The development of this e-module has produced a PjBL-based electrical circuit E-module that is valid, practical, and has a positive impact on the results of the electrical circuit lectures for semester 2 students majoring in electrical engineering education, Manado State University. Thus, this PjBL-based E-module can be applied to lectures on electrical circuits both in class activities and carried out independently by students. Through the results of the development of the E-module which has been proven to be valid, practical and has a positive impact on the results of lectures on electrical circuits, second semester students majoring in electrical engineering education at Manado State University are advised to use this E-module. This e-module is for studying electrical circuits in order to gain a meaningful learning experience, train independence, while increasing conceptual understanding of the material taught in this e-module. Then it is recommended that lecturers in charge of the course use the results of this E-module research as an example of a framework for developing E-modules with other topics. For other researchers who will carry out development research with similar techniques or topics, it is recommended to pay close attention to the process of developing this E-module.

7 References

[1] P. M. Thana, U. Musamus, S. Hanipah, and U. Musamus, "Kurikulum Merdeka: Transformasi Pendidikan SD Untuk Menghadapi Tantangan Abad ke-2".

[2] M. Zulfadhilah *et al.*, "PEMANFAATAN TEKNOLOGI DIGITAL PADA PROSES PEMBELAJARAN DENGAN PENDEKATAN COMPUTATIONAL THINKING," *SELAPARANG*, vol. 6, no. 3, p. 1134, Sep. 2022, doi: 10.31764/jpmb.v6i3.9206.

[3] I. D. Isnaini and M. P. Ariyanti, "PENGEMBANGAN MEDIA AUDIOVISUAL LAGU ANAK TEMATIK MELALUI KREATIVITAS MAHASISWA".

[4] R. Rusmini, D. Emilyani, and A. Dramawan, "Efektivitas Model Pendekatan Manajemen Coaching Bimbingan Akademik Terhadap Indeks Prestasi Mahasiswa Jurusan Keperawatan," *jppni*, vol. 7, no. 1, p. 26, Mar. 2023, doi: 10.32419/jppni.v7i1.364.

[5] R. Damaiyanti, M. T. Akbar, and M. Prasrihamni, "ANALISIS KEMAMPUAN BERFIKIR KREATIF SISWA PADA PEMBELAJARAN IPS KELAS 4 SD," vol. 09, 2023.

[6] F. A. Hasibuan and T. Hasibuan, "Efektivitas Pembelajaran STEAM Berbasis PJBL Dalam Meningkatkan Kreativitas Mahasiswa Teknik Sipil Mata Kuliah Mekanika Fluida Dan Hidrolika".

[7] K. T. Yunianto, B. E. H. Cahyono, and S. Budyartati, "Pengaruh model pembelajaran PJBL terintegrasi STEM terhadap kemampuan berpikir kritis pada mata pelajaran IPAS kelas IV MIN 2 kota madiun".

[8] H. Sb, "THE IMPLEMENTATION OF PROJECT BASED LEARNING MODELS IN TEACHING AND LEARNING PROCESS OF ENGLISH FOR NURSING AT NURSING STUDY PROGRAM OF AKPER KESDAM I/BUKIT BARISAN PADANG," vol. 2, no. 2, 2023.

[9] T. Wariani and V. H. B. Hayon, "Kajian Tentang Keaktifan, Hasil Belajar, dan Produk yang Dihasilkan Mahasiswa Pada Perkuliahan yang Menerapkan Pembelajaran Berbasis Proyek," *ijes*, vol. 5, no. 2, pp. 134–142, Aug. 2023, doi: 10.31605/ijes.v5i2.2371.

[10] A. G. A. G. Sukmadewi and J. Jumadi, "Development of Mobile Learning Based E-Module to Improve Concept Understanding and Interest Learning X Class Student in Momentum and Impulse," *jppipa, pendidikan ipa, fisika, biologi, kimia*, vol. 9, no. 8, pp. 5914–5920, Aug. 2023, doi: 10.29303/jppipa.v9i8.3565.

[11] E. Kristiana, F. R. Hadi, and L. N. Pradana, "Pengembangan e-modul matematika menggunakan flipbook.".

[12] N. N. Rusmini, I. W. Lasmawan, and I. M. Candiasa, "DEVELOPING DIGITAL TEACHING MODULE OF SOCIAL-SCIENCE SUBJECT BASED STEAM METHOD FOR GRADE FOUR ELEMENTARY SCHOOL STUDENTS: Pendidikan Dasar," *ijed*, vol. 4, no. 2, pp. 150–157, Aug. 2023, doi: 10.59672/ijed.v4i2.2974.

[13] P. Hayati and R. N. Fauziah, "Pengembangan E-Modul Eksperimen Fisika Berbasis Project Based Learning," vol. 05, no. 03, 2023.

[14] S. Rejeki, I. P. Leksono, and U. Rohman, "Pengembangan E-Modul Berbasis Canva Model ADDIE Mata Pelatihan Pembuatan Konten Video Interaktif dalam Pembelajaran pada Pelatihan TIK MTS di Balai Diklat Keagamaan Surabaya," vol. 4, 2023.

[15] M. U. Amrin, I. Sentryo, N. Sumarna, and W. O. L. Arisanti, "PENERAPAN MODEL PEMBELAJARAN PROJECT BASED LEARNING (PjBL) DENGAN MENGGUNAKAN MEDIA AUGMENTED REALITY UNTUK MENINGKATKAN HASIL BELAJAR SISWA PADA MATERI BANGUN RUANG DI KELAS V SD," vol. 5, 2023.

[16] I. Sukma, "PENERAPAN MODEL PEMBELAJARAN PJBL UNTUK MENINGKATKAN HASIL BELAJAR IPA SISWA KELAS VI SD," *JP*, vol. 8, no. 2, pp. 1567–1578, Aug. 2023, doi: 10.23969/jp.v8i2.9702.

[17] N. Yuniarti, D. L. B. Taruno, M. Ali, T. Sukisno, and M. Muhfizaturrahmah, "Development of an Industrial Electrical Installation Training Unit," *JEE*, vol. 7, no. 2, pp. 87–103, Jun. 2023, doi: 10.21831/jee.v7i2.60431.

[18] P. Ojha, A. Sun, A. Raja, J. Varley, C. Agg, and L. Stringer, "CREATING A MODULE TO EMPOWER ENGINEERING STUDENTS TO BECOME CHAMPIONS FOR EQUALITY, DIVERSITY, AND INCLUSION," in *Proceedings of the International Conference on Engineering and Product Design Education, EPDE 2023*, The Design Society, 2023. doi: 10.35199/EPDE.2023.43.

[19] U. N. Halim and M. K. Sari, "PENGEMBANGAN E-MODUL BERBASIS FLIPBOOK UNTUK MENINGKATKAN LITERASI DIGITAL SISWA PADA KURIKULUM MERDEKA".
[20] Y. D. Alfana, E. Fernandes, and I. Yuliady, "INOVASI MODEL PEMBELAJARAN BERBASIS PROYEK PADA MATA KULIAH TEKNIK PENGELASAN UNTUK MENINGKATKAN BERPIKIR KREATIF MAHASISWA," no. 3, 2023.
[21] M. R. Latif and M. Muskhir, "Pengembangan Buku Ajar Pada Matakuliah Rangkaian Listrik Program Studi Teknik Elektro Industri," *JTEV*, vol. 6, no. 1, p. 365, Mar. 2020, doi: 10.24036/jtev.v6i1.108036.
[22] R. Yevira, "PENGEMBANGAN E-MODUL BERBASIS SETS UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS SISWA".
[23] A. F. Luhuringtyas and L. E. Rahmawati, "IMPLEMENTASI MODEL PEMBELAJARAN BERBASIS PROYEK DENGANSISTEM BLOK DALAM PEMBELAJARAN BAHASA INDONESIA BERBASISTEKS".
[24] M. C. Purba and B. Sujatmiko, "PENGEMBANGAN E-MODUL INTERAKTIF BERBASIS WEBSITE DENGAN MODEL PEMBELAJARAN PROJECT BASED LEARNING UNTUK MENINGKATKAN MINAT BELAJAR SISWA PADA MATA PELAJARAN PKWU DI SMKN 10 SURABAYA," vol. 08, 2023.

8 Authors

I Gede Budi Mahendra is a lecturer in the Electrical Engineering Education Department, Faculty of Engineering, Universitas Negeri Manado (email: igedebudimahendra@unima.ac.id).

Janne Deivy Ticoh is a lecturer in the Electrical Engineering Education Department, Faculty of Engineering, Universitas Negeri Manado (email: jdticoh@unima.ac.id).

Djami Olii is a lecturer in the Electrical Engineering Education Department, Faculty of Engineering, Universitas Negeri Manado (email: djamiolii@unima.ac.id).

Usman Nursusanto is a lecturer in the Electrical Engineering Education Department, Faculty of Engineering, Universitas Negeri Yogyakarta (email: usmannursusanto@uny.ac.id).