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STEAM (Science, Technology, Engineering, Arts and Mathematics) Based Electronics Module on Fifth Grade Elementary School Electrical Components Material

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Abstrak

*Tantangan dalam penerapan kurikulum merdeka adalah kesiapan guru dalam menggunakan teknologi digital untuk pembelajaran. Guru dituntut untuk dapat menggunakan teknologi namun masih banyak yang kesulitan dalam mengembangkan media digital untuk pembelajaran. Tujuan penelitian ini yaitu untuk mengembangkan modul elektronik berbasis STEAM dalam pembelajaran pada materi komponen listrik untuk kelas V Sekolah Dasar. Jenis penelitian ini yaitu penelitian pengembangan dengan menggunakan model pengembangan 4D (*Define, Design, Develop, dan Disseminate*). Subjek penelitian yaitu ahli media, ahli materi pembelajaran, dan ahli bahasa. Subjek uji coba yaitu 5 guru dan siswa. Metode pengumpulan data yang digunakan dalam penelitian ini meliputi wawancara, angket, dan tes. Instrumen yang digunakan untuk mengumpulkan data yaitu lembar kuesioner. Teknik yang digunakan untuk menganalisis data adalah analisis deskriptif kualitatif, statistik kuantitatif dan inferensial. Hasil penelitian yaitu menunjukkan adanya perbedaan yang signifikan antara sebelum dan sesudah menggunakan modul elektronik berbasis STEAM dan sesudahnya. Disimpulkan bahwa modul elektronik berbasis STEAM dapat meningkatkan kemampuan berpikir tingkat tinggi siswa. Penelitian ini menggarisbawahi potensi alat pembelajaran e-modul, khususnya dalam konteks pendekatan STEAM, dalam meningkatkan hasil pendidikan. Implikasi penelitian ini yaitu modul elektronik berbasis STEAM dapat digunakan dalam pembelajaran.*

***Kata Kunci*:** *E-modul, STEAM, Berpikir Tingkat Tinggi*

Abstract

The challenge in implementing the independent curriculum is teachers ' readiness to use digital technology for learning. Teachers are required to be able to use technology, but many still need help developing digital media for learning. This research aims to develop a STEAM-based electronic module for class V elementary schools learning electrical components. This type of research uses the 4D development model (Define, Design, Develop, and Disseminate). The research subjects were media experts, learning materials experts, and language experts. The test subjects were five teachers and students. Data collection methods used in this research include interviews, questionnaires and tests. The instrument used to collect data was a questionnaire sheet. The techniques used to analyze data are qualitative descriptive analysis and quantitative and inferential statistics. The results of the research show that there is a significant difference between before and after using STEAM-based electronic modules and after. It was concluded that STEAM-based electronic modules can improve students' higher-order thinking abilities. This research highlights the potential of e-module learning tools, particularly in the context of a STEAM approach, in improving educational outcomes. The implication of this research is that STEAM-based electronic modules can be used in learning.

Keywords: E-modules, STEAM, Higher Order Thinking

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1. INTRODUCTION

Implementing an independent curriculum to increase student motivation in subjects has been going well and has increased over several semesters. The advantage of using an independent curriculum is that teachers can be creative and innovative in learning activities to make learning activities more meaningful (Saadah et al., 2022). In the learning process, teachers have the freedom to choose various learning tools so that learning can be tailored to students' learning needs and interests. In this curriculum, there is a project to strengthen the achievement of the Pancasila student profile (Jamaludin et al., 2022; Kahfi, 2022;

Setiyaningsih & Wiryanto, 2022). Learning activities are also project-based and must be completed by students so that students are challenged to learn. The independent curriculum is a curriculum with intracurricular learning with a variety of content so that it will be more optimal for students to deepen concepts and strengthen competencies (Fuadi & Irdalisa, 2022; Nursalam et al., 2023). The materials presented are limited to essential materials. Students are also given more freedom to choose subjects they are interested in according to their talents and aspirations (Safitri & Ananda, 2023; Setiyaningsih & Wiryanto, 2022). Learning activities like this certainly have a positive impact on students

However, the current challenge in the independent curriculum is the improvement of learning facilities. Implementing the Independent Curriculum aims to train students' soft skills through various schools and learning activities (Nugrohadi et al., 2022; Wahyudin et al., 2022). Other findings also reveal that learning facilities are critical for every school to have so that learning activities can run optimally (Rahmawati et al., 2021; Sholihah & Mufidah, 2021). The lack of learning facilities certainly impacts learning objectives that need to be achieved optimally. Learning facilities have the function of helping students learn (Mandey, 2021; Widiarti et al., 2021). Another challenge in implementing this independent curriculum is the readiness of human resources (teachers) (Sasmita & Darmansya, 2020). Teachers act as the central pillar of implementing the independent curriculum. In this case, teachers are drivers of the success of various independent learning programs such as differentiated learning, project implementation, strengthening Pancasila student profiles and learning assessments, and empowering technology as a learning support tool. Previous research states that some teachers must be proficient in using various technological tools (Asari et al., 2019; Desi, 2020; Suchyadi et al., 2021). Mastering technology will make it very easy for teachers to carry out the teaching and learning process, especially in teaching using a curriculum that requires teachers to use digital technology. Teachers must also be able to use learning approaches based on the independent curriculum.

The solution to overcome these learning problems is to use digital learning media that can support learning activities. Teachers must be able to utilize digital technology as an appropriate means of communication and networking to access, manage, integrate, evaluate and create information that functions in learning (Handayani, 2021; Nahdi & Jatisunda, 2020). Many learning aids utilize electronic media, such as ICT, multimedia, television, and computer technology (Desi, 2020; Listiaji & Subhan, 2021). However, only a few educators take advantage of learning modules that utilize electronic media. Electronic media can help the effectiveness of the learning process in circumstances or situations where it is not possible to do it face to face (Septiana & Hanafi, 2022; Suchyadi et al., 2021). The use of digital technology makes the learning process at school more accessible. Teaching materials are essential to implementing education in schools (Tanjung & Fahmi, 2015; Yulaika et al., 2020). Based on this, one of the learning media that teachers can use to support learning activities is STEAM (Science, Technology, Engineering, Arts and Mathematics) based E-modules.

Electronic modules are a form of presentation of independent learning material that is systematically arranged into minor learning units to achieve specific learning goals. E-modules are presented in electronic format, which includes animation, audio, and navigation, which makes users more interactive with the program (Darwis et al., 2020; Faidar et al., 2023). E-Modules are also defined as digital and systematic teaching materials that contain a set of planned learning experiences and are specifically designed to help students learn and master learning materials (Asrial et al., 2020; Herawati & Muhtadi, 2018). The electronic module developed is equipped with STEAM. STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. STEAM can motivate teachers in designing project-based learning activities, unites 5 disciplines, namely technology, art, science, mathematics

and engineering, and can also produce a comprehensive learning space (Mariano & Chiappe, 2021; Perignat & Katz-Buonincontro, 2019). The STEAM approach aims to make students skilled in solving everyday problems and ready to work in the 21st century. The benefits of the STEAM approach were found to develop creativity and attract students' attention (Bahrum et al., 2018; Siregar et al., 2020).

Previous research findings state that using E-modules can function as a substitute for the function or role of facilitator/educator so that it will help students when learning independently (Rahayu & Sukardi., 2020; Sitorus et al., 2019). Other research also reveals that E-modules are student reference material (Farenta et al., 2016; Maharani Zan & Mardian, 2022). Other research also reveals that STEAM learning concepts can improve students' thinking abilities (Ahmad et al., 2021; Bedar & Al-Shboul, 2020). It can be concluded that STEAM-based E-Modules can help students learn. However, there has yet to be a study regarding STEAM-based E-Modules in learning electrical component science material for fifth-grade elementary school students. The advantage of the STEAM-based E-Module that will be developed is that the STEAM-based E-Module is a learning medium and tool in elementary schools to motivate student learning and increase students' understanding of concepts to create more effective and efficient learning activities. Based on this, this research aims to develop a STEAM-based E-Module in learning electrical component material science for fifth-grade elementary school students.

2. METHODS

The 4D development model (*Define, Design, Development, and Dissemination*) is used in this type of research and development (R&D). Test instruments are given to teachers and students to measure the effectiveness of e-module products, and validation questionnaires are used to verify the validity of e-module products by media, material, and language validators. Data collection using questionnaires and instrument tests. This research on e-module development involves two main phases of testing. Firstly, it includes validation testing conducted by media and material experts to assess the effectiveness of the e-module learning media. Secondly, practicality and effectiveness testing is carried out with student class V and teachers from SD IT Al Firdaus. Upon validation by experts and if deemed feasible, a trial phase will commence involving from SD Al Firdaus, who will utilize the e-module for learning. Following completion of the learning sessions, both teachers and students will provide feedback through response and assessment questionnaires, which will be used for potential improvements to the e-module.

The study incorporates both quantitative and qualitative data. Qualitative data is gathered from student response questionnaires, input from grade 5 teachers, and feedback from media experts. Quantitative data, on the other hand, includes validation assessments by experts, questionnaires from students and teachers, as well as pretest and posttest score analyses. Data collection methods employed in the research include interviews, questionnaires, and tests. To identify initial issues, researchers conducted unstructured interviews with parents and grade students class V. The instruments used to collect quantitative data are validation questionnaires given to expert teams, response results from students and teachers and tests (Kosasih, 2021; Purwono, 2014). The instrument grids in this study can be seen in Table 1, and Table 2.

Table 1. Material Expert Instrument

No.	Aspect	Indicator	Numbers
1	Material Aspect	The material has KI and KD	1
		The material is in accordance with the indicators	2
		The material is in accordance with learning objective	3
2	Learning Aspect	Accuracy of the concept	4
		Novelty of the material	5
		The aligment of the example given	6-8
		Clarity of learning indicators	9
3	Content feasibility	The suitability of ilustrations, images, and videos is clear	10-13
4	Language	Grammatical accuracy	14,16
		Sentence accuracy	17,18
		Language used is developmentally appropriate	19
		Ability to increase curiosity student	20

Table 2. Media Experts Instrument

No.	Aspect	Indicator	Numbers
1	Programming	Serving Menu	1
		Intructions for use	2
		Ease of use	3
2	Display	Letter	4,5
		Text Readability	6
		Distance usage	7
		Layout	8
		Background	9
		Navigation Buttons	10
		Presentation of Images, Audio, and Video	11-17
		Inter-Pagepresentation	18-20

The data classification phase of this research project employs a conversion chart, which encompasses a product validation conversion table compiled by material specialists, experts in digital teaching materials, and response questionnaires. Data on the responses of students and teachers in the form of *rating scales* using Likert scales 1-5 as an assessment will be calculated the percentage of questionnaires calculated by the formula. The techniques used to analyze data are qualitative descriptive analysis, quantitative and inferential statistics. Qualitative descriptive analysis was used to analyze data in the form of input provided by experts regarding STEAM-based E-modules. Quantitative analysis is used to analyze data in the form of scores given by experts regarding STEAM-based E-modules. Inferential statistical analysis is used to analyze the effectiveness of STEAM-based E-modules.

3. RESULTS AND DISCUSSION

Result

During this phase, researchers examine student textbooks, field conditions, and student circumstances to identify challenges encountered by students in online teaching and learning activities during the pandemic. Through the review of student textbooks, it was observed that grade 5 students at SD IT Al Firdaus Nogosari utilized integrated thematic books aligned with the 2013 curriculum revised in 2017. The topic of simple electrical

circuits is covered in Theme 3, Subtheme 1, where the material elaborates on the source of electrical energy, its components and functions, and the process of assembling an electrical circuit. However, it was evident that students faced difficulties in fully grasping the material solely through reading and visual aids.

Interviews with students and parents revealed that during online learning, students struggled to absorb the provided material optimally, resulting in difficulties and forgetfulness regarding simple electrical circuit concepts despite being taught the material. Consequently, parents with higher incomes opted to enroll their children in private educational institutions or supplementary tutoring sessions outside of school hours. Conversely, parents from lower economic backgrounds found it burdensome to afford additional learning opportunities outside of school, leading them to refrain from registering their children for private tutoring. During this phase, researchers examine student textbooks, field conditions, and student circumstances to identify challenges encountered by students in online teaching and learning activities during the pandemic. Through the review of student textbooks, it was observed that grade 5 students at SD IT Al Firdaus Nogosari utilized integrated thematic books aligned with the 2013 curriculum revised in 2017. The topic of simple electrical circuits is covered in Theme 3, Subtheme 1, where the material elaborates on the source of electrical energy, its components and functions, and the process of assembling an electrical circuit. However, it was evident that students faced difficulties in fully grasping the material solely through reading and visual aids.

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The design of the media involves conceptualizing the display of the e-module using Microsoft PowerPoint. The material design is tailored to align with the indicators of the curriculum's basic competencies, incorporating content compiled from various sources such as books and the internet. Additionally, learning videos sourced from YouTube are integrated into the material, selected to correspond with the learning indicators, aiming to facilitate deeper understanding of the subject matter for students. The media design phase, coupled with material design, offers several advantages. It streamlines the process for researchers to advance to the subsequent stages of development, ensuring that the prepared material is reliable due to the careful selection of content that aligns with basic competencies and indicators.

This phase aims to actualize the media and material designs developed in the previous stage. The development of the e-module design utilizes the Unity 19 application. Subsequently, validation tests are conducted by both media and material experts. The purpose of these tests is to ensure that the planning and development of the media are more targeted with guidance and input from experts in the respective fields. Any feedback or revisions suggested by the experts are incorporated before the media is presented to students. E-module development showed in Figure 1.

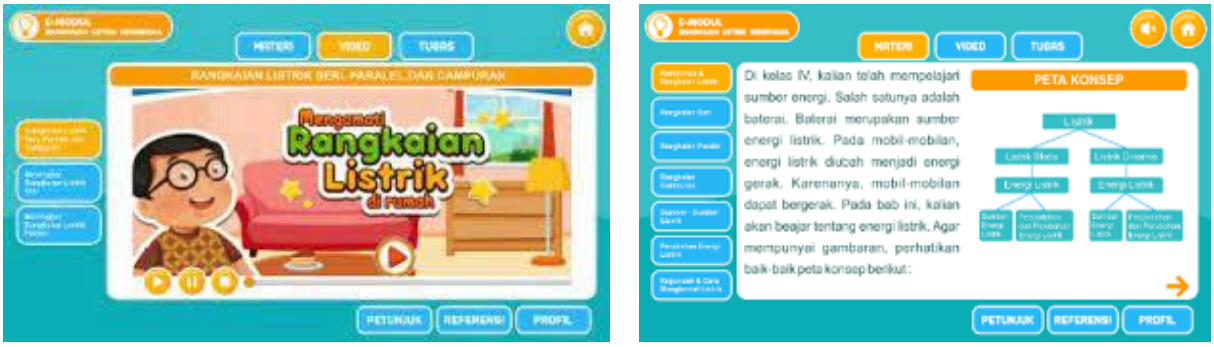

Figure 1. E-module Development

Media validation serves the purpose of evaluating the developed media and serves as a basis for enhancing or revising learning materials, aiming to achieve optimal outcomes. The validation process encompasses material validation, validation of learning media, validation of teacher and student questionnaire sheets, as well as validation of pre-test and post-test questions. Validation of the e-module learning media, specifically for the topic of simple electrical circuits, was conducted by expert evaluators. Based on data analysis, the average percentage of overall media expert validation results is 82. If you look at Table 1 of the eligibility criteria, then this score is included in the very decent category. When validating, there is input and criticism from validators which is used as material to improve and revise electronic modules before being tested on students. Furthermore, media validator input and suggestions are to change the background color to make it look brighter, replace the background on the initial display with a more attractive image, all designs in the theme change are equalized, change the font type and size to be larger.

The next stage is the validation of linguists in terms of straightforward, communicative, diagnostic and interactive aspects, suitability with student development, conformity with language rules, and the use of terms and symbols. Based on data analysis, the average percentage of overall validation linguists obtained was 89. If you look at Table 5 of the eligibility criteria, then this score is included in the very decent category. When validating, there are inputs and criticisms from validators that are used as material to improve and revise electronic modules before being tested on students, while input and suggestions from language validators are the layout of symbols, EYD, and adjusted capital letters, writing the source on each image entered, writing for English or foreign words in italics.

The next stage is material expert validation in terms of aspects of material content and presentation, as for the results obtained from material expert validation. Based on data analysis that the average percentage of overall validation linguists obtained was 89. If you look at Table 1 of the eligibility criteria, then this score is included in the very decent category. When validating, there are inputs and criticisms from validators that are used as material to improve and revise electronic modules before being tested on students, while input and suggestions from language validators are the layout of symbols, EYD, and adjusted capital letters, writing the source on each image entered, writing for English or foreign words in italics.

The next stage is material expert validation in terms of aspects of material content and presentation, as for the results obtained from material expert validation. Based on data analysis, the average calculation percentage at the one to one trial stage was 85. This shows that the flipbook-shaped electronic module product developed is very feasible. The input obtained during the one-to-one trial is as follows: 1) There are some sentences that are not clear so it is difficult to understand, and 2) the choice of background color in theme 8 material is not right so it is a little annoying. From the previous stage, namely one to one

trials, input from students became revised material for the next electronic module product. Then the revised product is tested in a small group. At this stage, the trial was conducted by five students selected based on different levels of knowledge using an 11-question questionnaire. Based on data analysis, the average result of the calculation percentage at the small group trial stage was obtained at 90. This shows that the flipbook-shaped electronic module product developed is good. The input obtained during the small group trial was to add cartoon animation to the electronic module and There were questions that confused students. Here is what the electronic module looks like after fixing based on validator input and suggestions.

The next stage is field trials, the data obtained from the results of field trials are the results of student learning which includes cognitive domains which include evaluation values and competency tests with the C4-C6 question domains, namely analysis, evaluation and creating which are part of improving higher-order thinking skills. In this field trial, the task is in the form of pretest, post test and project. Before the electronic module is applied in the learning process, learners are given *a pretest* first. The *pretest* questions consist of 5 essay questions. After conducting the *pretest*, a learning process was carried out in the form of STEAM project activities. To analyze the improvement of students' higher-order thinking skills, a prerequisite test is carried out first, namely the normality and homogeneity test if the data is normally distributed and homogeneous, then the next test uses the *paired sample t-test*. The summary of trial results in Table 3.

Table 3. Description of *Pretest* and *Post Test Results*

Test Type	Sum Learners	Mean	Standard Deviation	Value Minimum	Value Maximum
Pretest	24	68.33	8.297	55	80
Post test	24	86.46	8.531	75	100

Based on data students' *pretest* and *post-test* results, it is known that the average learning outcomes of students before applying learning with STEAM-based electronic modules was 68.33 with a standard deviation of 8.297 and the minimum value obtained was 55 and the maximum value was 80. The average obtained after applying learning with STEAM-based electronic modules was 86.46 with a standard deviation of 8.531 and obtained a minimum score of 75 and a maximum value of 100.

Based on *pretest* and *post test* values, it can be used to determine the effectiveness of learning using STEAM-based electronic modules with a normalized *N-gain* formula. The normalized *N-gain* results of student learning outcomes were obtained on average of 58.02. The average achievement amount shows that learning outcomes using STEAM-based electronic modules are categorized as moderate. After getting normalized *N-gain results*, then the learning results are carried out prerequisite tests. Prerequisite tests are performed before *the paired sample t-test* is tested. The results of the analysis of *pretest* and *post test* values of higher order thinking skills (HOTS) showed in Table 4.

Tabel 4. Test result Paired Sample T-test

Test type	Normality	Homogeneuty	Paired Sample Ttest
Pretest	0.051 (Normal)	0.053 (Homogen)	Sig (0.000)
Post test	0.059 (Normal)		

The results of data analysis show that the pre-test and post-test data are normal and homogeneous because > 0.05. The t-test results show that the sig value is 0.00 so that 0.00 <

0.05. This shows that there is a significant difference between before using STEAM-based electronic modules and after, so it is stated that STEAM-based electronic modules can improve the high-level thinking abilities of high-level students.

Discussions

The data analysis results show a significant difference between before and after using the STEAM-based electronic module and after. Several factors cause this. First, STEAM-based electronic modules can improve students' higher-order thinking abilities. STEAM-based learning integrates science, technology, engineering and mathematics learning, which is recommended to help the success of skills in education in the 21st century (Başaran & Bay, 2022; Perignat & Katz-Buonincontro, 2019). STEAM is a practical learning approach because, in this STEAM approach, students can combine knowledge, technology, mathematics and engineering. The general goal of STEAM-based learning is to be able to apply and practice the basics of STEAM content in situations and circumstances faced and encountered in life to improve students' higher-order thinking abilities (Mariano & Chiappe, 2021; Perignat & Katz-Buonincontro, 2019). The benefits of STEAM include encouraging independent thinking and promoting an interdisciplinary approach (Erol et al., 2022; Perignat & Katz-Buonincontro, 2019).

Second, STEAM-based electronic modules can make it easier for students to learn. E-learning modules are a medium that students can use independently (Laili et al., 2019; Oksa & Soenarto, 2020). A good e-module must be arranged systematically, attractively and clearly. Modules can be used anytime and anywhere according to student needs. Previous findings reveal that using modules in the learning process increases students' ability to learn independently without depending on the presence of educators (Muzijah et al., 2020; Priatna et al., 2017). STEAM-based electronic modules will undoubtedly make it easier for students to learn. According to the 2013 curriculum, STEAM learning emphasizes the learning process so that students can understand various materials using a scientific approach (Başaran & Bay, 2022; Perignat & Katz-Buonincontro, 2019). The benefits of using e-modules become apparent during implementation because they can stimulate students' motivation and enthusiasm for learning so that, ultimately, they can improve learning outcomes (Darmayasa et al., 2018; Yuyun et al., 2022).

Third, STEAM-based electronic modules can increase students' enthusiasm for learning. The STEAM method is a learning concept that combines knowledge from five fields in learning activities. STEAM is a learning approach that provides opportunities for students to expand their knowledge in developing the skills needed to develop in the 21st century, such as communication skills, critical thinking skills, leadership, teamwork, creativity, resilience and other skills (Bahrum et al., 2018; Siregar et al., 2020). Students can actively participate and contribute to learning. Using e-modules as an Android application will foster an impressive learning experience for students, thereby increasing students' enthusiasm for learning and ultimately improving learning outcomes (Lestari et al., 2021; Winatha et al., 2018). In addition, e-modules provide a more exciting learning experience because of the visually attractive interface and the inclusion of learning videos that help better understand the material (Asrial et al., 2019; Priatna et al., 2017).

Previous research findings state that E-modules can stimulate students learning so that they can improve student learning outcomes (Maharani Zan & Mardian, 2022; Suarsana et al., 2021). Other research also confirms that E-modules are suitable for use as a learning tool because there is a change in the learning style of children who used to learn so monotonously teacher-centred; with the use of electronic modules, children learn more flexibly, communicatively and independently (Sa'diyah, 2021; Simamora et al., 2019). The difference and superiority of this research with previous research lies in the approach used. The STEAM

approach is beneficial in basic skills in the 21st century; students understand theory and practice it directly by conducting experiments or research. The limitation of this research is that it only develops STEAM-based E-modules for fifth-grade elementary school students. This research implies that the STEAM-based E-module developed is suitable for use in learning and successfully improves students' high-level thinking skills. E-modules are an ideal learning medium because they offer accessibility anytime and anywhere.

4. CONCLUSION

The results of data analysis show that the TEAM-based electronic module, based on validation results from media, language and material experts, has received very good qualifications. This STEAM-based electronic module teaching material received a positive response from the results of one-to-one and small-group trials conducted on students. The t-test results also show a significant difference between before and after using the STEAM-based electronic module and after. It was concluded that STEAM-based electronic modules can improve students' higher-order thinking abilities.

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