



STEM-Based Science E-Module: Is It Effective to Improve Students' Creative Thinking Skills?

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Abstract

Elementary school students need to be able to think creatively, especially when facing various obstacles in their future careers. Therefore, it is necessary to develop STEM-based e-modules that can improve the creative thinking skills of elementary school students. This study aimed to describe how well STEM-based e-modules improved students' creative thinking skills about electrical energy. The subjects of this study were 30 students in sixth grade in MIN 2 Pringsewu, using the learning achievement test as a research instrument. Descriptive qualitative was used as the data analysis. The N-gain test was also used to evaluate the data. Based on the study's results, the electronic module was declared effective with an N-gain score of 0.7, which was determined from data analysis. Thus, it is assumed that e-modules based on the STEM approach were claimed to be able to develop students' creative thinking abilities further.

Keywords: creative thinking; effectiveness; e-module; STEM

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INTRODUCTION

Learning is changing people from being ignorant to being more knowledgeable (Fatonah & Yunianto, 2021; Hartini et al., 2018). The correlation in experiences that develop the student's abilities are supported by different parts of learning within a framework, one of which is teaching materials (Sari et al., 2017; Hidayah, Komikesari et al., 2023). One of the learning tools that can help students succeed in the learning process is teaching materials (Muslem et al., 2019; Setiawan et al., 2017). Teaching makes learning more effective and efficient (Desyandri et al., 2019; Sari et

al., 2017). Thus, the teaching materials used in learning must be of high quality, interesting, innovative, fun, and up-to-date (Diansah & Asyhari, 2020a). In Indonesia, these innovations must be adapted to the K-13 (2013 curriculum) because they are inseparable from educational policies (Gustiani et al., 2017). One of the curriculum policies is the "student-centered approach," which explains in detail that the module is one of the learning resources that supports the implementation of the information into practice (Gustiani et al., 2017; Priyanthi et al., 2017). The module is one of the methodically planned teaching



materials, basically based on a designed educational program that can be focused flexibly within a certain time (Salampessy & Suparman, 2019; Setiyadi et al., 2017).

Modules have advantages such as assisting students in the development of their ability to interact with the environment and learning materials, making the learning process more interesting because it can be done anywhere, available to test the learning outcomes through questions in the module and supporting the students according to their learning styles based on their interests and abilities (Irwandani et al., 2017; Priyanthi et al., 2017; Tjiptiany et al., 2016). The learning modules used today are not only in the framework of printed modules; given the advances in printed module technology, these modules can also be formed into electronic modules (Diansah & Asyhari, 2020b; Hidayah, Masykuri, et al., 2023).

One of the independent teaching materials that are methodically arranged in the minor learning units to achieve optimal learning goals is an electronic module (e-module) (Adlim et al., 2015; Yunni, 2015). One type of digital-based teaching material is an e-module. These materials are factual, conceptual, effective, and efficient, making packaged learning more interesting and motivating students to learn. The content in e-Modules is not only in the form of writing. However, it is also supported by images, audio, video, and animation, thus enabling students to understand complex material concepts through quality teaching materials (Agus et al., 2017; Destiyana, 2016; Misbah et al., 2021; Priyanthi et al., 2017). The development of quality teaching materials is an effort to find breakthroughs and a result of innovation in the learning process that influences the cultivation of students' understanding of the values, character, and culture of the nation by the times (Diansah &

Asyhari, 2020a; Hidayah et al., 2023; Nurramadhani et al., 2020).

According to the National Science Teachers Association (NSTA), students must be able to think critically and solve problems to succeed in education in the 21st century (Tohir, 2021; Zakiyah & Sudarmin, 2022). However, based on the results of the Trends International Mathematics and Science Study (TIMSS) in 2015 and the results of the PISA survey (Tohir, 2019). With a score of 382, Indonesia was ranked 64th out of 65 countries in 2012 (Tohir, 2021). In 2015, Indonesia scored 403 in 64th out of 72 countries (Tohir, 2021). Then, in 2018, Indonesia was in 74th position out of 79 countries with a score of 396 (Gurria, 2018: 18). From 2012 to 2018, the results of the PISA survey showed that Indonesia was ranked in the bottom 10 for the third time in a row. Assuming that it is determined using tabular/realistic information, only 4%. ISLE in Italy (2015) states that Indonesia has consistently shown poor STEM performance since the International Student Assessment Program was implemented. From a ranking of 70 countries, Indonesia is ranked 62nd in the field of science and 63rd in the field of mathematics. This fact shows that Indonesia's ability to study science and technology is very low (Mata et al., 2021; Herak & Lamanepa, 2019).

One of the newest developments in the world of education is the STEM (Science, Technology, Engineering, and Mathematics) curriculum (Zakiyah & Sudarmin, 2022; Zhou et al., 2023) because it combines the four principles of a combination of learning science, innovation, design, and mathematics. Proposed as one of the efforts to advance 21st-century skills, STEM is a world-renowned learning approach that effectively implements Integrative Thematic Learning (Agung et al., 2022; Widiawati et al., 2022).

The STEM-based approach can enable students to have the opportunity to improve their metacognitive, fundamental, critical thinking skills, and creative reasoning skills through STEM-based instruction (Hallström et al., 2023; Hartini et al., 2020; Li, 2023; Meishanti & Maknun, 2022; Syukri et al., 2021). STEM education approach is also ready to prepare students psychologically, emotionally, and in terms of their abilities (Chen et al., 2024; Hammack et al., 2024). In addition, students are educated hypothetically and trained so that they experience a true measure of learning (Parmin et al., 2020; Prasetyo et al., 2021; Zhou et al., 2023). As a result, STEM can be used to teach science in new ways. Due to intense competition for graduates who can compete in today's world of work, the use of the STEM approach in science education is not only a necessity but also a demand (Gustiani et al., 2017; Herak & Lamanepa, 2019; Lestari et al., 2018; Saputri et al., 2023; Zhou et al., 2023)

Science learning is discovery-based learning that combines, consolidates, and coordinates science learning in a unified whole, in which learning is completed in a coordinated way (Maric et al., 2023; Muallimuna, 2017; Setyowati & Fimansyah, 2018). Utilization of the STEM approach in learning science is a new form of innovation that can enable students to have the ability to master and have advantages that include deliberate reflection, imagination, creativity, and equipped for correspondence and joint efforts (Gui et al., 2023; Novelia et al., 2022; Setyowati & Fimansyah, 2018; Syukri et al., 2021). The development and manifestation of learning to convey material that is guided and shown expertly, sincere, consistent and fun and combined in an individual way that is close to the real environment to build students' abilities in and to achieve learning goals appropriately (Anggereini

et al., 2023; Hallström et al., 2023; Hammack et al., 2024).

Seeing the consequences above, it is considered that the learning sources used by the teacher in the learning cycle are less effective in assisting students in learning, so students have difficulty understanding the material, especially in online learning. This results from the limited use of reading instructors in learning activities. If the learning material influences students' attitudes and independence, then students will understand the material better. With these problems, it is hoped that there will be efforts to help students and collaborate with them in adapting freely (Gui et al., 2023; Maric et al., 2023). STEM-based electronic modules are packaged attractively by adding animations and projects to each material and explanations of each STEM component, including science, technology, engineering, art, and mathematics (Wu et al., 2023). This STEM-based electronic module can improve students' high-level thinking skills and be used as a tool in independent learning (Costello et al., 2023; Hutomo et al., 2022; Sari & Sutihat, 2022). Making quality teaching materials is one of the approaches researchers can take to develop STEM-based science e-modules to learn about the "Effectiveness of STEM Approach-Based Science e-modules to Improve Creative Thinking Skills of Sixth Grade Elementary School Students" based on the previous background.

METHOD

This research involved research and development in creating results and determining their effectiveness (Sugiyono, 2020). The research method used was descriptive research and development with a qualitative approach. It was intended that research data can be presented properly and the data obtained can be explained in detail (Almuharomah

et al., 2019). The research subjects were the sixth-grade students of MIN 2 Pringsewu, who had 30 research subjects. The essay test instrument for creativity consisted of five items, each of which represented indicators of creative thinking, such as fluency, flexibility, elaboration, and originality (Rahman et al., Stolaki & Economides, 2018).

Field trials were carried out on the sixth-grade electrical energy material with a STEM learning approach. The trial design used Two groups: pre-test and post-test. A comparison was made between the results of the learning outcomes test before and after using electronic modules based on the STEM approach to electrical energy material, which was developed to improve students' creative thinking abilities. Table 1 shows the characteristics of students' creative thinking levels.

Table 1 Characteristics of creative thinking category

Category	Characteristics of Creative Thinking Levels
Very creative	The students can answer 4 with the correct answer
Creative	The students can answer 3 with the correct answer
Enough Creative	The students can answer 2 with the correct answer
Less Creative	The students can answer 1 with the correct answer

The data was analyzed in percentage form. Furthermore, the data is processed using the N-Gain statistical test. The results of the N-gain statistical test determined the categories, namely high, medium, and low (Hake, 1999). The magnitude of the influence of the application of the STEM-based integrated science e-module to improve students' creative thinking skills was carried out using the effect size.

The effect size interpretation criteria can be seen in Table 2.

Table 2 Interpretation effect size

Effect Size	Interpretation
$0,8 < d < 2,0$	High effect
$0,5 < d < 0,8$	Medium effect
$0,2 < d < 0,5$	Low effect

RESULTS AND DISCUSSION

This research was conducted in two different classes, namely, the experimental class and the control class. In the experimental class, a STEM learning approach was implemented, namely a learning model that emphasized students to carry out independent and more meaningful learning supported by teaching materials in e-modules.

The science e-module used was an electronic module that experts have validated. In the science e-module, electrical energy material is presented with text and uses videos, animations, and interactive quizzes. The following is a display of the science e-module. The STEM-based science e-module display is shown in Figure 1.



Figure 1 (a) In science, students are directed to build curiosity and openness by asking questions to generate new ideas, (b) In the field of technology, it displays technology as an object, knowledge, and activity where environmental aspects are obtained from the process of solving problems and developing new products, (c) In the field of engineering, several experiments are presented to build their own experiences and provide opportunities to build science skills and mathematical knowledge through design analysis and scientific inquiry, and (d) In the area of mathematics, the students are aimed to evaluate the available designs

The data tested were the mean and standard deviation data from the post-test results of the students, as shown in Table 3.

Table 3 Results of output mean and std. deviation

Class		Statistic
Control	Mean	66.33
	Std. Deviation	8.08
	Mean	86.17
Experiment	Std. Deviation	5.97

The effect size test using Cohen's formula shows an effect size of 0.07. The N-gain value is in the medium category; the N-gain value is 0.7. Thus, the Integrated Science Electronic Module based on the STEM approach is influential and effective for improving the creative thinking skills of sixth-grade SD/MI students. This is in line with research (Feola et al., 2023; Sari & Sutihat, 2022), which stated that this STEM-based electronic module can improve students' high-level thinking skills and be used as a tool in independent learning.

Some of the advantages of STEM-based E-Modules compared to printed modules are that they are more practical to carry everywhere, durable and do not rot over time, can be equipped with audio and video in one presentation bundle, and each learning activity can be given keywords that are useful for locking learning activities. Students must master one learning activity before moving on to the next one. In this way, students can complete learning activities in stages. On the other hand, this STEM-based E-module has five stages in its implementation in the classroom, namely 1) Observe, where students are motivated to observe various phenomena/issues found in the daily life environment that are related to the scientific concepts being taught, 2) New Idea, students observe and look for additional information about various phenomena or issues related to the science topic being discussed, then students carry out the new idea step. Students are asked to look for and think of a new idea from the existing information. In this step, students need analytical and hard thinking skills; 3) Innovation. In this innovation step, students are asked to describe what must be done so that the ideas generated in the previous new idea step can be applied. 4) Creation. This step is the implementation of all suggestions and views resulting from discussions regarding the ideas they want to apply, and 5) Values (Society). The final step that students must carry out, and what is meant here, is the value that the ideas produced by students have for actual social life.

STEM Approach-based e-modules have a positive effect on student learning. The STEM approach to

learning can train students both cognitively and skillfully; apart from that, students are taught theoretically and practically so that students experience the learning process directly. Through the STEM approach, students have learning and innovation skills, which include thinking critically, creatively, and innovatively and being able to communicate and collaborate.

Another advantage of STEM-based e-module products regarding electrical energy and its changes is material aspects (Costello et al., 2023). The material on electrical energy and its changes is combined with a STEM approach so that the material has aspects of Science, Technology, Engineering, and Mathematics that involve phenomena that occur in everyday life, which will enable students to understand the material of electrical energy and its changes so that they can improve creative thinking. Learners. The material on electrical energy and its changes contained in this e-module is packaged in the form of theory and videos, as well as explanations assisted by picture features, which make it more interesting and easy for students to understand. The designed STEM-based E-Module can encourage students to play a more active role because students directly carry out simple practicums for each sub-material.

Evaluation results are obtained from the results of the implementation stage by examining the advantages and disadvantages of the media created. The advantages of these results can be used as a reference for further research. Meanwhile, the disadvantages of the research are 1) the research time was very limited so that the learning process could not be carried out optimally, and

2) the smartphone/media should be compatible with the use of applications. It caused the class test to be limited only to the researchers who used laptops as learning media 3) The modules developed were only limited to electrical energy material.

CONCLUSION

Based on the research results conducted to test students' creative thinking skills, the N-gain increased by 0.7 and was included in the medium category. So, it can be concluded that the effectiveness of science e-modules based on the STEM approach can improve the creative thinking skills of the sixth grader students in MIN 2 Pringsewu. However, there were still a lot of weaknesses due to several factors, one of which was the limited time in the research. Thus, further research and development is necessary to improve the Science e-Module based on the STEM approach to support learning activities more effectively. Students and teachers assume open materials in STEM-based e-modules are needed to improve students' creative thinking abilities. Furthermore, it is hoped that the results of this research can be used as a strong basis for developing STEM-based e-modules to improve students' creative thinking abilities through Research and Development (R&D).

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