

Learning Electric Circuits Using the STEM Approach to Improve Scientific Thinking Skills and Practice

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Abstract

This study aimed to determine the effectiveness of using the STEM approach in learning direct electric circuits to achieve high school students' scientific and practical thinking skills. This research is a quasi-experimental method. This study used two class groups, namely the experimental class and the control class, with the experimental class being the class group that received the STEM learning treatment. In contrast, the control class was the class group that only received the immediate learning model treatment. The research design uses a non-equivalent control group design. The research was carried out in the even semester of 2021-2022 and the place of this research was one of the schools in Serang City, Banten province. The sample consisted of two classes; one class was given the learning treatment with the STEM approach, which served as the experimental class, and the other class received no therapy and functioned as the control class. Each course has 40 students, including 20 male and 20 female students. The average age of students is 17 years. The instrument used in this study was in the form of 10 essay questions. This question covered electric current circuit material with indicators of scientific thinking ability and practice. The instrument used in this study was in the form of 10 essay questions. This question covered electric current circuit material with indicators of scientific thinking ability and practice. The data obtained after the research will be analyzed using N-Gain data analysis. The N-gain result in the experimental class was 0.67, while the control class was 0.46. The N-Gain results of the two types show the same category, namely the good category. However, the N-gain results from the experimental class show a value greater than 21% than the control class. These results prove that learning electric circuits using STEM is more effective than learning directly. The implications of this research are 1) It can foster an understanding of the relationship between the concept of electric circuits with practical skills in assembling electric current circuits, 2) Arouse students' curiosity and activate creative imagination and critical thinking, 3) Help students to understand and experiment with the scientific process.

Keywords: Electric current circuit, STEM approach, Ability to think scientifically and practice

INTRODUCTION

The main problem in learning for high school students is the low value of physics learning outcomes in electric current circuit material. Based on the results of observations and interviews conducted with teachers and students, it was shown that during the learning process of electric current circuits, several problems were found, namely: (1) learning activities still used discussions so that students were not or less active in the learning process, (2) learning activities still using the conventional one-way approach, (3) the results of the evaluation of learning on electric current circuit material for the last five years (2018-2022) on average are still low, namely obtaining a score of 60 out of a maximum score of 100.

It can be seen from the learning conditions that do not touch the students' dimensions, namely, the learning process. In a broad sense, the learning process still dominates the teacher and does not allow students to develop independence through discovery in their thinking processes. The electric current circuit is one of the interesting and very important materials for every student to learn to develop the ability to think scientifically (Gilbert, 2013). Electric current circuits are a scientific science that requires understanding and conducting experiments to be able to understand and master concepts and be able to apply them in solving everyday life problems (Hubber & Tytler, 2017; Sládek et al., 2011).

Based on the problems above, one effort is made to create an interesting and fun learning of electric current circuits using the STEM (Science, Technology, Engineering, Mathematics) approach (Biberman-Shalev, 2021; Pollock et al., 2021). STEM is a learning approach that involves all students actively in learning activities (Braaten et al., 2022; Sharma et al., 2021). The research results show that STEM can attract students' attention and interest in learning and improve the results of students' higher-order thinking skills (Fan & Yu, 2017). The STEM approach is used to overcome students' difficulties in learning (Domènech-Casal, 2019; LaForce et al., 2016). STEM can create a learning atmosphere that is directly related to everyday life (Gülen, 2018; Kurup et al., 2019). STEM can also make students understand the various concepts being taught (Pujiastuti & Haryadi, 2023). Through the STEM approach, students can remember physics concepts longer (Haryadi & Pujiastuti, 2022).

This study will use the STEM approach to help students improve electric current circuit material learning outcomes. This STEM approach can create a learning system by linking knowledge and skills. The following is a description of the learning process that uses the STEM approach (Hong, 2019; Struyf, 2019; Tomkin, 2019): 1) Science represents knowledge about the concepts and laws that apply in nature, 2) Technology is a system used to manage society, organizations, and knowledge using an artificial tool to facilitate work, 3) The technique is the knowledge of operating a procedure to solve a problem, 4) Mathematics is a science that connects quantities, numbers, and space without being accompanied by empirical evidence.

Of the four aspects that have been described, STEM can make knowledge more meaningful if it is applied to the learning process. STEM focuses on developing students' science skills and problem-solving skills (Holmlund et al., 2018; McFadden & Roehrig, 2017). When using STEM, the teacher must be a facilitator, monitoring and assessing student progress and offering assistance according to student needs (Haryadi & Pujiastuti, 2020). Using the STEM approach, students can behave like scientists or engineers (Scalise, 2018; Yoon &

Strobel, 2017). Through learning using the STEM approach, students can share their work and ideas with their classmates (Gil-Doménech, 2019; Kim, 2019; Sudarmin, 2019).

STEM is a teaching and learning approach between two or more STEM approaches used in the learning process intended to increase students' interest in pursuing higher education and careers in these fields (Rainey et al., 2019; Reinholz & Apkarian, 2018). The integration of STEM education in teaching and learning can be applied at all levels of education, from elementary school to university, because aspects of STEM implementation, such as intelligence, creativity, and design ability, do not depend on age (Barak, 2018; Julià, 2019).

The STEM approach can prepare students to develop the skills needed in everyday life. By implementing the STEM learning approach, students are guided to find answers to the material being taught so that they are actively involved in learning (Bell et al., 2018; Saptarani, 2019). Based on other research shows that the application of STEM can help develop knowledge, help answer questions based on investigations, and can help students to create new knowledge. STEM can increase mastery of knowledge and apply knowledge to solve problems (Haryadi et al., 2021).

The novelty of this research is the influence of the STEM approach in the learning activities of electric current circuits on students' scientific thinking skills and independent practice. The limitations of the problem in this study are that it is only applied to the material of direct current electric circuits and alternating electric current circuits. The objectives of this research include:

1. To find out the improvement of students' thinking skills and practice using the STEM approach to electric current circuit material.
2. To determine the effectiveness of learning electric current circuits using the STEM approach.

METHOD

Research design

The research used a quasi-experimental method with the design of two class groups: the experimental and control classes. Furthermore, the experimental class is the class group that gets the learning treatment with the STEM approach, while the control class is the class group that only gets the direct learning treatment.

The research design uses a non-equivalent control group design, including pretest, treatment, and posttest. The research design can be seen in Figure 1 (Creswell, 2013).

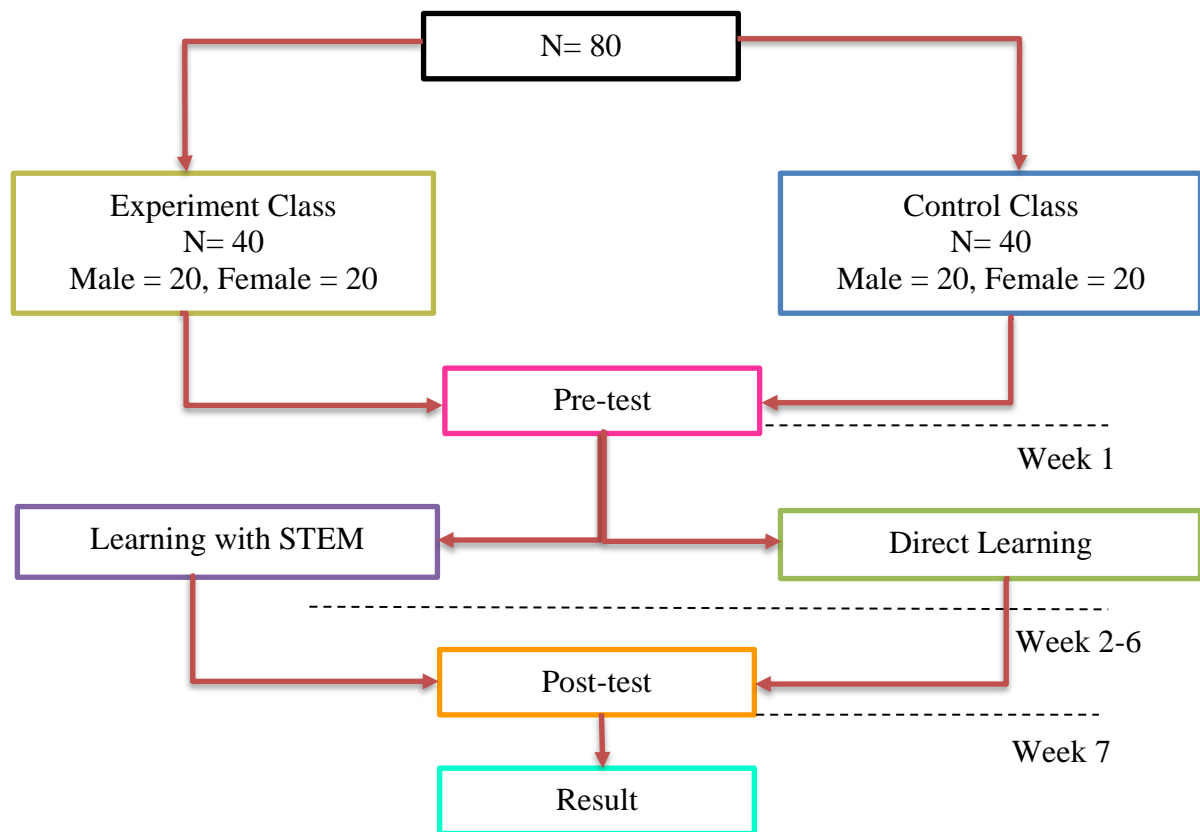


Figure 1. Research design

Time and Place of Research

The research was carried out in the even semester of 2021-2022, to be precise, in March-May, and the place of this research was in one of the schools in Serang City, Banten province.

Population and Sample

The population used in this study were class X students at one of the schools in Serang City, Banten province, for the 2021-2022 academic year. The sample in this study was taken freely according to the needs and design of this study; the sample consisted of two classes. One class was given the learning treatment with the STEM approach, which functioned as an experimental class, and the other class did not receive treatment and functioned as a control class. Each class consists of 40 students, including 20 male and 20 female students. The average age of students is 17 years.

Research Instruments

The instrument used in this research was in the form of 10 essay questions. Validation of the essay assessment is carried out through three stages, namely the initial stage, revision, and final stage. The initial stage aimed to get suggestions for improvement from the validator on the essay assessment that has been made. Suggestions and improvements from the validator are

used as guidelines for revising the essay assessment that has been made. After being revised, the assessment essay is ready for final validation by the validator until an essay assessment is obtained that is truly valid for testing. At this stage the questions have been declared valid and obtained a value of 0.5. This question covered electric current circuit material with indicators of scientific thinking ability and practice. The questions are given at the pretest and posttest.

2.5 Data Analysis

The data obtained after the research will be analyzed using N-Gain data analysis. This analysis is used to see any differences in the increase in scientific thinking skills and practice in the experimental and control classes. Judging from each student's score increases between the pretest and posttest. Here's the N-gain formula (Hake, 1998). The N-gain interpretation is presented in Table 1.

Table 1 . Interpretation of N-gain values

Score N-gain	Classification
$g \geq 0.7$	Tall
$0.7 \leq g \leq 0.3;$	Currently
$g < 0.3.$	Low

RESULTS AND DISCUSSION

Scientific Thinking Skills and Practice

The following are the results of the N-Gain analysis in the experimental class and control class which can be seen in Figure 2.

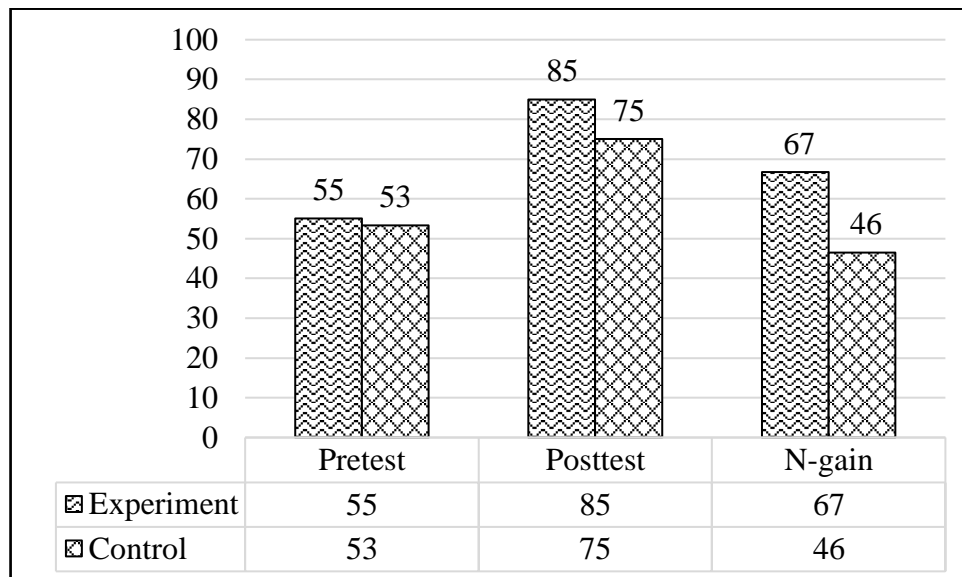


Figure 2. N-Gain in the Experiment Class and Control Class

Figure 2 shows that the N-gain result in the experimental class is 0.67 while the control class is 0.46. The N-Gain results of the two classes show the same category, namely the

sufficient category. However, from the experimental class, the N-Gain results showed a value that was 21% greater than the control class. These results prove that learning electric circuits using STEM is more effective than learning directly.

In the experimental class, the condition of the students at that time did not know and understand the concept of electric current circuit learning material, the results of a low pretest score of 55 evidence this condition. This result is because students are still not familiar with the material regarding electric current circuits. Most students do not understand the concept of electricity when carrying out learning activities. This activity occurred precisely at the second meeting. The students were asked to make a series-parallel electric current circuit with each group. In this process, there is an increase in knowledge about the ability to think scientifically and practice in students with the STEM approach.

At the next meeting, students are free to discuss and exchange ideas about the learning material being discussed so that students are more active in participating in discussion activities. After several weeks of carrying out learning activities using the STEM approach, students are given a posttest to determine the increase in scientific thinking skills and practice achievement. The posttest results showed that the differences in student achievement increased more than the results of the previous pretest. This condition proves that students begin to understand and know the concept of electric current circuits.

In the control and Experiment classes, students know nothing about electric current circuits. Just like the experimental class, the control class started learning as usual after carrying out the pretest. Still, it did not carry out activities in the form of making series-parallel current circuits as the experimental class did. This control class carries out direct learning activities in a conventional way.

Several factors cause the low results of students' scientific and practical thinking abilities, including the learning model used is still conventional. This is because students cannot be actively involved and only become listeners when carrying out learning activities. Because with STEAM learning, students will be trained in every behavior or character, and with science, students can implement knowledge in a tool skill in technology (Ibáñez, 2018; Jong, 2019). Technology will later be used to make or design something and followed by techniques that can be used to arrange methods coherently (Wu et al., 2018). And mathematics can be used to analyze and find solutions to problems (Kranzfelder, 2019; Landrum et al., 2017).

Besides that, STEAM learning can also instill a mindset in students to always prioritize solutions, and innovation, form independence, think rationally and understand technology. The following is what happened in the experimental class about learning electric current circuits.

No	Content on STEM	Description
1	Science	The teacher explains how electrical circuit tools can work properly. Students understand well the ability to think scientifically.
2	Technology	The teacher explains how to make the electric current circuit device, the current flow type, and the obstacles that occur. Students already understand the understanding of currents and obstacles that occur.
3	Engineering	The teacher explains adjusting the electric current circuit to produce high power for incandescent lamps. Students begin to be skilled in doing practice assembling electric current circuits.
4	Mathematics	The teacher explains how to calculate the value of the incoming and outgoing currents. Students can calculate precisely according to users, which can be applied in everyday life.

CONCLUSION

The conclusion of this study states that students' achievement of scientific thinking skills and practice for the experimental class is included in the moderate category with an achievement percentage of 67%. The control class is included in the moderate category with a percentage of 46%. The effectiveness of learning electric current circuits using the STEM approach is better than using direct learning. As for suggestions for further research to be better, namely that the applied STEM is more developed, especially for other physics materials.

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