The influence of science, technology, engineering, and mathematics (STEM) learning approaches on learning outcomes

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Abstract. The objective of the study is to discover the effect of the Science, Technology, Engineering, and Mathematics (STEM) learning approach on the physics learning outcomes. The study is considered as quasi-experimental research by implementing the non-equivalent, pretest-posttest as the research design. There were two science classes of SMA Negeri 1 Sindue Tobata were selected as the sample of the study. The Science, Technology, Engineering, and Mathematics learning approach was applied to the experimental class while the scientific approach was applied to the control class. The learning outcomes test obtained showed that the average score of the experimental group was 15.95 and the average score of the control group was 12.25. Based on the results of hypothesis testing, obtained that \( t_{\text{count}} = 3.00 \) and \( t_{\alpha(0.0975(38))} = 2.024 \) at a significance level of \( a = 0.05 \). It means that the value of \( t_{\text{count}} \) is outside the acceptance area of \( H_0 \). The findings concluded that there were differences in physics learning outcomes between the students who were taught by using STEM approach and the students who were only taught by implementing the scientific approach in SMA Negeri 1 Sindue Tobata.

1. Introduction

The industrial revolution of education in the 21st century is the education that requires each student to have skills, knowledge, and abilities in the fields of technology, media and information, learning skills, innovation, life skills, and competencies [1–3]. The 21st century is well known as the century of knowledge, a century in which science and technology are developing rapidly. Therefore, the resources that have high competitiveness in the globalization era are highly needed. The technological developments are not possible to be separated from the contribution of physical science development since physics is a science that studies natural events and phenomena [4]. Physics is one of the interesting studies because it is directly correlated to the actual phenomenon and can also be applied in daily activities.

Lesson delivering process in physics learning should involve the concepts and real life phenomena [5], because the comprehension in physics requires more than just memorizing skills [6]. Teachers should be able to create learning environment that could enable students to think, assume and construct the knowledge independently [7]. However, the physics lesson in reality tends to be taught with the concept of memorizing. It causes many students to experience difficulties in learning physics especially when they implement the concepts of physics in their daily life [8]. It occurs...
because teachers usually give less relevant examples of physics subjects with real life phenomena.

The emphasis on comprehending the basic concepts and the basic understanding of science is not in accordance with matters relating to everyday life, whereas Harefa [9] reveals that physics is a science that is closely related to human life. It is what causes the low ability of students either in the field of physics or other fields of studies, which then also causes low student learning outcomes.

Based on the study conducted by Fatmawati [10] at SMA 4 Jember, it can be known that the low students’ learning outcomes are caused due to the tendency of the teacher to apply the conventional learning method in the educational process, in which the process of learning only centered to the teacher while the students can only listen to the material explained by the teacher. It causes students to be less active in the learning process as well as the tendency of the students to only memorize the material but do not understand the topic being taught. In addition, since the educational process is central to the teachers, they tend to only elaborate the material monotonously without correlating the concepts of physics to everyday life. It is actually causing the low students’ learning outcomes. Therefore, the learning approach which able to connect the physics subject into everyday activity is needed so that the learning process could be more meaningful and improve students’ activeness in the learning process so that the students not only memorize but also comprehend the material being taught. The solution to overcome the problem is to apply an approach in the learning process, one of which is the STEM approach.

The STEM approach is an approach that refers to four components of knowledge, namely science, technology, engineering, and mathematics [11]. In line with the statement, research shows that the application of STEM is able to facilitate the students to develop knowledge, help answer questions based on investigation, and can help students to create new knowledge [12].

STEM is designed to improve people’s abilities in knowledge and innovative technology products in order to be able to compete globally [13]. The aim of STEM education for students is expected to be able to deliver students to meet 21st-century abilities, including learning and innovation skills. The STEM learning approach by integrating the four components is able to improve students’ physics learning outcomes which are characterized by the ability in solving problems, making decisions, analyzing assumptions, evaluating and conducting investigations. The STEM approach which is integrated in learning has the potential to equip students with 21st-century work skills through learning outcomes [14]. Learning outcomes are an indication of the ability of students’ work skills, the extent to which the contribution of the influence of STEM learning on learning outcomes in the form of creativity, problem-solving skills, and students’ self-motivation.

The implementation of the STEM approach is very important to student learning outcomes, it is supported by the research conducted by Muthi’ik, it was concluded that the STEM learning approach is effective for increasing student self-efficacy and student learning outcomes [15].

According to the research conducted by [16], it was concluded that STEM learning trains students’ creative abilities in connecting the four fields of exact disciplines so that students have deep and dynamic insights in solving global issues. Then STEM learning also affects student learning outcomes. The purpose of this study is to determine whether there is an influence of the Science, Technology, Engineering, and Mathematics learning approach on the physics learning outcomes of the students of SMA Negeri 1 Sindue Tobata. The advantages of this study are as consideration for selecting the learning model to be applied to achieve optimal physics learning outcomes

2. Methods

The study was quasi-experiment research, with the non-equivalent pretest-posttest control group design. The treatment group was taught using science, technology, engineering, and mathematics (STEM) approach, while the control group was taught using scientific approach. The samples were 11 students of science classes and were selected using the purposive sampling. The two selected classes are classes that are considered academically homogeneous. Based on the observation, the number of students in both classes was equal and have homogeneous learning outcomes, which is seen from the learning outcomes at the previous semester in the final semester examination in which the average score obtained by the students in both classes was 86.

The technique of data collection in this study was in the form of object tests and observation
Sheets. Objective tests were used to measure student learning outcomes after learning treatment was given. While the observation sheets were used to assess the activities of students and teachers during the learning process.

The research instrument used was an objective test for multiple-choice developed by the researcher. This test has been checked by expert validators. This special test for learning outcomes consists of 25 numbers that were used twice, such as at the beginning (pretest) and the end (posttest) which were in accordance with the indicators. After that, the instrument was tested to measure the validity, the level of difficulty of the questions, the distinguishing power, and the reliability of the items. The instrument used in this study was first checked by the validator, before being tested and used for research. The results of the statistical test obtained that 21 items were accepted, 4 were revised and 25 items were rejected because they did not meet the criteria.

The normality, homogeneity, and hypothesis testing were carried out to analyze the result of the study. Normality testing was carried out to see whether the data obtained from the research results were normally distributed or not, the homogeneity of variance test was used to determine whether the variance between the two classes was the same or different, and hypothesis testing was used to see whether the formulated hypothesis was supported by the data that has been collected.

3. Results and Discussion

The pretest-posttest of students’ learning outcomes can be seen in Table 1. Overall, the posttest results increased for both the control and treatment groups.

| Description    | Pretest  | Posttest  |
|----------------|----------|-----------|
| Sample (n)     | 18       | 18        |
| Minimum score  | 8        | 7         |
| Ideal score    | 30       | 30        |
| Maximum score  | 16       | 16        |
| Average score  | 11.28    | 11.39     |
| Standard dev.  | 2.38     | 2.68      |

To test the hypothesis, normality and homogeneity test were conducted. The results of these tests are presented in Table 2 and 3.

| Description    | Posttest |
|----------------|----------|
| Sample         | 20       |
| $\chi^2_{count}$ | 2.29     |
| $\chi^2_{table}$ | 5.99     |

According to the Table 2 by using the Chi-Square test with acceptance criteria $\chi^2_{count} < \chi^2_{table}$ in which the final test of $\chi^2_{count}$ value obtained is smaller than the value of $\chi^2_{table}$. Based on the decision-making criteria, $H_1$ is accepted. These results indicate that the data from the experimental class and control class are normally distributed. Meanwhile, information in Table 3 indicated that the value of $F_{count}$ is lower than the value of $F_{table}$. In the acceptance criteria, it can be concluded that the data in the experimental class and control class have equal variance (homogeneous).
In the learning process, the teacher could also guide the students, creativity, science, mathematics. Finally, the scientific approach in the problems denoted that the outperformance the scientific group, both groups indicated an increase in learning outcome. It was conducted using the parametric-based on the data. The detailed results can be seen in Table 4.

### Table 4. The t-test on the final test (posttest)

| Description | Final Test (posttest) |
|-------------|----------------------|
| $t_{count}$ | 3.00                 |
| $t_{table}(\alpha = 0.05)$ | 2.024               |

Based on the data in Table 4, the $t_{count} > t_{table}$ or $3.00 > 2.024$. It shows that the value of $t_{count}$ is in the rejection area of $H_0$, thus the $H_1$ is accepted. It denotes that there is an effect of the implementation of STEM approach on students’ learning outcomes on physics. The results indicate that students’ cognitive achievement in treatment were better compared to students who were in control group. It is owing to the implementation of STEM in the teaching and learning process, which enables students to examine the lesson learned that occur in daily life. In the learning process conducted with the STEM approach, the teacher guided students to be able to observe daily-life problems (Observe) that were displayed by using video assistance (Technology). The problems were associated with physics (Science), which was the concept of sound waves. After that, brainstorming was conducted to stimulate thoughts and new ideas that can be used to solve the problems. The teacher could provide explanations about technology engineering techniques (Engineering) by utilizing the concept of sound waves. The teacher afterward could give guidance to the students to be innovative (Innovation) in developing the ideas that have been obtained by the students through group discussion along with their friends. The teacher could also guide the students to be able to model a physics problem into the form of a mathematical formula (Mathematics). Subsequently, the teacher guides students to be able to think creatively (Creativity) in solving physics problems using the assistance of LKPD. Finally, the last process carried out by the teacher in learning is directing students to be able to draw conclusions and relate the material to everyday life (Society).

Meanwhile, the scientific approach was implemented for the learning process in the control class. In contrast to the STEM approach which requires students to be able to think innovatively and creatively in solving problems, the scientific approach requires students to solve problems through careful planning activities, data collection, data analysis, and drawing conclusions. Problem solving steps involve observing, questioning, gathering information, reasoning, and communicating. Students were provided worksheets after lesson delivering. During problem solving processes, students could question the teacher and find the solution and required information through peer discussion. At the reasoning step, the teacher asks each group to summarize the results of the discussion and draw conclusions. Finally, at the last step to communicate the teacher assigns representatives of each group to present the results of the discussion. However, the application of the scientific approach in the learning process was still less effective. It was due to the uneven ability of students. Students were not familiar with the stages, especially during scrutinizing the correct information among the abundant information in the Internet. In addition, there were many errors done by students during the experiments which resulted in inference errors [17]. Although the students in STEM group outperformance the scientific group, both groups indicated an increase in learning outcome. It denoted that the scientific approach also give positive impacts on learning [18–20].
4. Conclusion
Based on the result, it could be concluded that there is an effect of learning outcome of students who were taught using the STEM approach in physics. However, despite the positive impact on physics learning, STEM application requires a longer time in the learning process. On that account, good preparation is necessary to be apply to integrate this approach in teaching physics.

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