The influence of STEM (science, technology, engineering, and mathematics) learning approach on students' learning outcomes on newton's law concept

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Abstract. STEM (Science, Technology, Engineering, Mathematics) is an approach that integrates science, technology, techniques, and mathematics in learning. This study aims to determine the effect of the STEM learning approach on students' learning outcomes on the Newton law concept. This research was conducted at SMA Darussalam Ciputat School from March 2020 to April 2020. In this study the experimental class was class X IPA 1, while the control class was X IPA 2. Determination of the sample based on this study was using purposive sampling technique. The research method used is a quasi-experimental design with nonequivalent control design. The Data from the instrument were analyzed quantitatively, producing hypothesis test data against post-test data using the Mann-Whitney test at $\alpha = 0.05$ obtained sig values. (2-tailed) of 0.00 with the conclusion that is $H_0$ rejected and $H_1$ is accepted. The learning outcomes of students in the experimental class increased higher (N-Gain 0.68) compared to students in the control class (N-Gain 0.19). Students are interested in STEM learning approach (78.25%). The STEM learning approach can be used as the main choice in implementing physics learning so that it can improve student learning outcomes.

1. Introduction

It is common knowledge that physics lessons are a frightening subject, so that not a few students feel that physics is a difficult subject to understand [1]. This is in line with the preliminary study conducted in South Tangerang that 66.7% of students find it difficult to understand physics concepts on Newton's Law material with the sub-concept of Newton's Law of motion that seem abstract if the learning process that the teacher delivers at each meeting tends to use the same methods. Another reason is that solving physics problems requires the development of formulas that do not exist in books [2]. The low quality of the learning process and students' interest in physics lessons have an impact on the low student learning outcomes [3].

All of the sub-chapters on the subject of physics, Newton's law material with the sub-concept of Newton's Law of motion is a chapter that is considered difficult [4]. Most of the class X students at SMA Darussalam Ciputat feel that Newton's law material with the sub-concept of Newton's Law of motion is a difficult material to understand, this is because this material is conveyed abstractly, the
lack of student involvement in learning, the learning model used by the teacher is not suitable, and the low learning outcomes the students have. Therefore, teachers should be able to improve student learning outcomes through appropriate learning models [5]. One of them is through the adaptation of education that is applied in various developed countries, such as the STEM approach which is currently being developed rapidly in several countries and has proven effective in improving student learning outcomes [6]. STEM (Science, Technology, Engineering, Mathematics) is an approach that integrates science, technology, techniques, and mathematics in learning [7].

The author is worried that if students have low learning outcomes, the learning objectives cannot be achieved [8]. Based on the national education system, the formulation of educational goals, both curricular and instructional goals, uses the classification of learning outcomes according to Bloom which broadly divides them into three domains, namely cognitive, affective, and psychomotor. When the things that have been mentioned are not achieved in learning physics, the learning objectives are not achieved and have an impact on students’ ability to compete in the current era of technological development.

Therefore, a solution so that students can improve learning outcomes, the STEM (Science, Technology, Engineering, Mathematics) learning approach is used to solve this problem. STEM is an approach that integrates science, technology, techniques, and mathematics into learning which uses an interdisciplinary approach and its application is accompanied by problem-based active learning. Furthermore, 3p Learning explains that stem is a branch of science approach that integrates learning science, technology, techniques, and mathematics into an integrated learning pattern. According to HarriFirman (2015) the components of STEM learning include; science which covers physics, chemistry, geography, astronomy, and biology which discusses natural phenomena, both living and inanimate objects. Furthermore, technology, namely various human creations that make life better and easier. Then engineering is a skill to acquire and apply knowledge to design and construct various tools and machines that are useful for human life. The last component is mathematics which is used to examine the patterns, relationships, and interactions of the other three STEM components. STEM education means combining these four components by focusing on solving real problems in everyday life and work life [9].

2. Methods
The research activities were conducted at SMA Darussalam Ciputat, located in CiputatTimur, Kota Tangerang Selatan. Data collection was carried out for three weeks starting from March 15, 2020 to April 6, 2020. This research used a quasi-experimental method with the design nonequivalent Control Group Design as shown in Table 1. This design has a control group and an experimental group, but it cannot fully function to control external variables that affect the experiment [10]. The two groups were given different treatment. The experimental group was given treatment using the STEM learning approach, while the control group was given treatment using conventional methods that have been applied in the school.

Table 1. Research design.

| Group     | Pretest | Variable | Posttest |
|-----------|---------|----------|----------|
| Experiment| $O_1$   | $X_1$    | $O_2$    |
| Control   | $O_1$   | $X_2$    | $O_2$    |

The population in this study were all students of class X MIPA SMA Darussalam Ciputat. The Sampling is using purposive sampling technique. As for the consideration of researchers and teachers, the samples were taken from class X IPA I as an experimental class and X IPA II as a control class, because both classes have relatively the same academic abilities.
3. Results and Discussion

3.1 Recapitulation of the Pre-test and Post-test Results on This Results and Discussion

Data analysis of pretest and posttest results was carried out to see student learning outcomes before and after STEM-based physics learning was applied. After the pre-test and post-test data were obtained, they were analyzed descriptively. The results of descriptive data analysis can be seen in Table 2.

Table 2. Data recapitulation of the pre-test and post-test results in the control class and experimental class.

| Data Centering and Spreading | Pre-test          | Post-test         |
|-----------------------------|-------------------|-------------------|
|                             | Control Class     | Experiment Class  | Control Class | Experiment Class |
| Lowest Value                | 11                | 11                | 50            | 75               |
| Highest Value               | 55                | 58                | 78            | 98               |
| Mean                        | 34.5              | 25.43             | 62.82         | 84.04            |
| Modus                       | 38.5              | 21.5              | 62.00         | 82.00            |
| Median                      | 11                | 11                | 70            | 80               |
| Standard Deviation          | 14.11             | 13.9              | 8.007         | 6.449            |

Table 2 shows that the control class and experimental class have increased from the average value after being given different treatments. In the control class, the average value increased with the difference between the pre-test and post-test of 28.32. Meanwhile, the experimental class experienced an increase in the average value with the difference between the pre-test and post-test of 58.61. This shows that the experimental class that was treated in the form of the STEM (Science, Technology, Engineering, Mathematics) learning approach had a higher learning outcome than the control class that was given learning treatment with conventional methods.

Based on the pre-test data in the control class and experimental class, the mean score of the control class was 34.5 and the experimental class average score was 25.43. The average control class is higher than the experimental class. This shows that the average learning outcomes are still low. This is because at the time of the pretest students did not know the concept of the material to be studied. Therefore, the two classes were given different treatments, namely the control class used scientific learning with conventional learning methods, while the experimental class used the STEM learning approach.

Student learning outcomes increase in post-test results. The post-test mean score of the experimental class and control class students increased. The average score of the control class was 62.82 and the experimental class was 84.04. The increase in scores in the experimental class was higher than the control class, due to the different treatment given to the two classes. In the experimental class, students were given treatment with the STEM learning approach during the learning process while in the control class only conventional learning methods were used. This is in line with previous research that science learning is very appropriate to be combined with STEM[11].

In the control class, the increase in student scores was lower than the experimental class because learning took place in a teacher centered manner, so that students did not play an active role in the learning process. The process of learning physics using the lecture method makes students passive and if it is always used it will be boring [12].
3.2 The Results of the N-Gain Test on This Results and discussion

To determine the increase in student learning outcomes, the n-gain test was used on the pre-test and post-test results. The N-Gain test was carried out as a measure for improving learning outcomes in the control and experimental classes. The results of the N-Gain test can be seen in Table 3.

Table 3. The result of N-Gain.

| Learning Outcomes Indicator | Control Class | | | Experiment Class |
|-----------------------------|---------------|-----------------|-----------------|
|                             | Pre-test      | Post-test       | N-Gain          | Category       |
| Remembering                 | 58.8          | 73.5            | 0.36            | Medium         |
| Understanding               | 44.1          | 58.8            | 0.26            | Low            |
| Applying                    | 23.5          | 29.4            | 0.08            | Low            |
| Analysing                   | 26.4          | 44.1            | 0.24            | Low            |
|                             |               |                 |                 | Control Pretest |
|                             |               |                 |                 | Experiment Pretest |
|                             |               |                 |                 | Control Posttest |
|                             |               |                 |                 | Experiment Posttest |

Table 3 shows that the results of the N-Gain test in the experimental class increased in all indicators of learning outcomes compared to the control class. The experimental class had an increase in the learning outcome indicators in the high category, while the control class had an indicator of learning outcomes in the low category.

3.3 The Results of the Pre-test and Post-test of Student Learning Outcomes on This Results and discussion

Student learning outcomes on Newton’s law concept with the sub-concept of Newton’s law of motion can be seen from the pre-test and post-test results presented in Figure 1.

![Figure 1. Diagram of the results of the pre-test and post-test of student learning outcomes in the control class and the experiment class.](image-url)
Figure 1 shows that the increase in the learning outcome indicator for $C_1$ cognitive level (Remembering) and $C_2$ cognitive level (Understanding), the experimental class has a higher category than the control class. This shows that the STEM learning approach invites students to have thoughts, ideas or answers in understanding phenomena related to the concept of Newton's law. All aspects of the indicators of learning outcomes greatly affect students' mastery of concepts or knowledge in accordance with what they find scientifically [13]. This increase in the cognitive level is because in the STEM learning approach there is a research stage, where students dig up information from various relevant sources, so that it can help students understand problems and problems can be resolved [14].

The STEM learning approach can also improve learning outcomes at the $C_3$ cognitive level (Applying), where in the control class there is no increase, while in the experimental class it increases with the moderate category. This is because in the STEM learning approach there is an application stage, where students can solve problems by implementing the model they have designed, at this stage students test a model that has been designed to identify and understand the concept. STEM learning is a learning process that integrates Science, Technology, Engineering, and Mathematics. This process makes students understand the concept of learning as a whole [15].

Furthermore, on the analyzing indicator or $C_4$ cognitive level (Analysing) the experimental class increased by 0.58. The improvement of learning outcomes for this indicator is because there is one stage in the STEM learning approach, namely reflection. This stage brings students into a problem and provides motivation to investigate, interpret and analyze the problem.

### 3.4 The Results of the Response Questionnaire Analysation

This Results and Discussion

The results of calculating the student response questionnaire can be seen in Table 4 below:

| Questionnaire Indicators                        | Student Response Percentage | Interpretation |
|------------------------------------------------|----------------------------|----------------|
| The use of the STEM learning approach in the learning process | 79%                        | Very Strong    |
| The advantages of the STEM learning approach in the learning process | 80%                        | Very Strong    |
| Understanding of physics concepts              | 78%                        | Very Strong    |
| Improved student learning outcomes             | 76%                        | Very Strong    |

Table 4 shows that students gave positive responses regarding the STEM learning approach. On the indicators of using the STEM learning approach in the learning process, 79% of students responded positively, 80% of students strongly agreed with the advantages of the STEM learning approach compared to conventional methods, 78% of students better understood Newton's Law material with the sub-concept of Newton's law of motion with the STEM learning approach, and 76% of students experienced increased learning outcomes by using the STEM learning approach during the learning process. This shows that students are more interested in learning physics using the STEM learning approach compared to conventional methods. Likewise, research conducted by Sunyong Han, Robert Caparo, and Mary Margaret shows that STEM affects student achievement [16].

### 4. Conclusion

Learning using the STEM learning approach has a significant effect on student learning outcomes in Newton's law material. This can be seen in the statistical hypothesis test results which state the value of Sig. (2-tailed) (0.00) < significance level (0.05). The results of the N-Gain test in the experimental class experienced an increase in the learning outcome indicators that were superior to the control class. The improvement of learning outcomes indicators was superior at the cognitive stage.
$C_1$ (Remembering) and $C_2$ (Understanding), the experimental class had a higher category than the control class.

The results showed that physics learning with the STEM learning approach can improve learning outcomes, therefore this learning approach can be used as the main choice in implementing physics learning so that it can improve student learning outcomes. It is suggested for further research that the teacher or researcher can allocate time properly, because using the STEM learning approach requires a relatively long time to implement.

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