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The Effect of the STEM Approach on Learning Outcomes of Elementary School Students

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Abstract

The problem in this study is the low science learning outcomes of fifth grade students at state elementary school 2 wonodadi. This study aims to determine the effect of the Science, Technology, Engineering, and Mathematics (STEM) approach on students' natural science learning outcomes. The type of research used is quantitative research with quasi-experimental methods and research designs in the form of non-equivalent control group designs. Determination of the research sample using purposive sampling, with a research sample consisting of 57 students. The results of the hypothesis test showed that there was a significant difference in learning outcomes between the group that applied the STEM approach and the group that applied the scientific approach to science learning outcomes. From the results of the hypothesis testing, it can be concluded that there is an influence of the Science, Technology, Engineering and Mathematics (STEM) approach to the science learning outcomes of students in class fifth grade elementary school, and there are positive and significant differences in the STEM approach in the experimental class compared to the scientific approach in the control class towards science learning outcomes of class fifth grade students at state elementary school 2 wonodadi.

Keywords
learning outcomes; science; stem approach

I. Introduction

Education is one of the most important things in a person's life. Especially in the context of facing the Industrial Revolution 4.0 era which requires quality human resources with must-have 21st century skills. These skills include character, citizenship, critical thinking, creativity, collaboration, and communication. Education is also considered as a determinant of the quality of each person and has an important role in shaping the nation's next generation. Therefore, the quality of education must be improved in order to create human resources that are productive, innovative, creative, and can contribute to the life of society, nation and state. Schools as formal educational institutions are responsible for educating the life of the nation. Therefore schools need various supporting components to realize a good learning process and can improve student learning outcomes.

Through learning activities there will be interaction between educators and students, where educators can provide material and understanding related to certain concepts to students. According to Arfani (2019: 88) The nature of learning is a process of interaction between students and the environment, resulting in a change in behavior for the better. Learning is not just an interaction process for acquisition of knowledge but also the formation of attitudes in order to achieve the goals of national education. In the 2013 curriculum, there

is a learning concept called thematic learning. Thematic learning is learning that integrates various competencies from various subjects into one theme through a meaningful learning process that has been adapted to the development of students. Implementation of thematic learning that combines several subjects into a theme, is not treated the same as the learning outcomes, because the learning outcomes of thematic learning for each subject are still assessed separately.

One of the seven subjects at the school is Natural Science). Science is one of the important subjects in elementary school. In implementing this approach the researcher uses Thematic Theme Six. Thematic Theme Six itself is a theme that studies heat and its transfer (convection, conduction and radiation).

Science learning is learning related to everyday life and phenomena that occur in the universe. Even though it is related to everyday life, learning science is often considered difficult by students. This is further strengthened, if the technique used by the teacher still uses the lecture method which is less interesting and tends to be boring. This certainly affects the low science learning outcomes of students.

Advances in science and technology have had a major impact on various aspects of human life. Included in the world of education which is an effort to educate the life of the nation. With advances in technology, especially in the world of education, educators must be able to adapt and develop methods in learning activities with reference to 21st century skills. One solution that can be used in learning activities that refer to learning 21 is the Science, Technology, Engineering, and Mathematics (STEM) approach. The STEM approach has a very important role in the development of the world of education, the combination of these four disciplines is expected to become a new foundation in building a nation. In the opinion of Shernoff, et al (2017: 3) STEM is education that uses knowledge of science, technology, engineering, mathematics in a learner-centered learning environment. By using the STEM approach, students are taught to investigate a problem related to engineering and find a solution, as well as prove it with explanations based on real-world phenomena. The use of technology is also very important in the STEM approach to support more interesting learning, and can improve student learning outcomes. The relevance of this research to the research conducted by the author is that it has the same variable, namely the STEM approach, while the difference lies in computational thinking skills.

There are two related studies that are used to support this research. The first research was conducted by Loliyana et al (2022: 738). In this study, elementary school teacher education students at state universities in Lampung Province used the STEM 4.0 approach which facilitates students both individually and in groups to be able to understand certain concepts (IPA). This is supported by Information and Communication Technology (ICT)-based learning media, technologies that are important in online learning. Furthermore, activities in learning with the STEM approach can also increase cooperation and collaboration, especially in the simple product development process (Engineering).

The second study is Astuti, Nelly. et al (2021) in a study entitled "Implementation of science technology engineering and mathematics approach in learning to critical thinking skills of fifth-grade elementary school students in Lampung Province". From this study found research results which showed that there was a significant influence between learning with the STEM approach on critical thinking skills. This proves that the average final result of students' critical thinking skills in the experimental class is greater than the non-experimental class. Experimental class (68.695) and non-experimental class (61.250). The relevance of this research to the research conducted by the author is that it has the same variable, namely the STEM approach, while the difference lies in critical thinking skills.

The type of research used is quantitative research with a quasi-experimental method and a research design in the form of a non-equivalent control group design (non-equivalent control group design). Quasi Experiment itself is a research design that involves experimental and control groups, but does not use random assignment to create comparisons. The non-equivalent control group design is a research design that is almost the same as the pretest-posttest control group design, except that in this design the experimental group and the control group are not randomly selected. Determination of the research sample using purposive sampling, with a research sample consisting of 57 students. Purposive Sampling itself is a non-random sampling technique in which the researcher determines the sampling by specifying special characteristics that are in accordance with the research objectives so that they are expected to be able to answer research problems.

In this case, the writer writes this article because there are several influencing factors. The first factor is, learning is still not student-oriented (teacher centered). The second factor, students tend to be bored and less active. Third, the use of technology in the process of learning activities has not yet been implemented. Fourth, educators have not used STEM in learning activities. Then the last one is that the science learning outcomes of students tend to be low.

This research must be completed so that writers and readers can find out the effect of the STEM approach on the science learning outcomes of fifth grade students. The expected results of the research are that it can improve the abilities of fifth grade elementary school students through learning with the STEM approach, increasing students' understanding of the material that has been delivered using the Science, Technology, Engineering, and Mathematics (STEM) approach so that it can improve science learning outcomes fifth grade Elementary School. Then for educators it functions as a guide and input for educators about the STEM approach which can be used as a source of information or guidance and can be used by educators to provide updates and innovations in learning so as to create active and student-oriented learning (student centered)

II. Research Method

2.1 Research design

In this study, the non-equivalent control group design was used. The experimental class was given STEM treatment, namely the fifth grade class A, while the control class was given scientific treatment, namely fifth grade class B. The consideration in determining the control class and the experimental class was that the learning outcomes of the fifth grade class B, students were lower than that of fifth grade class B. Both of these classes get the same science learning but by using a different learning approach. In the experimental class, they were treated using the STEM approach to learning, while in the control class, the learning process was carried out using a scientific approach. To see more clearly, the research design is presented in Figure 5 below.

Information:

X = Treatment in the experimental class using the Science, Technology, Engineering and Mathematics (STEM) approach

O_1 = Pre test value in the experimental class

O_2 = Post test scores in the experimental class

O_3 = Pre test value in the control class

O_4 = Post test value in the control class

2.2 Instrumen

The research instrument is a tool used to measure natural and social phenomena observed by Sugiyono (2014: 102), one of the purposes of making the instrument is to obtain complete data and information about the things you want to study. The research instrument used in this study is test and non-test.

a. Test Instruments

The form of the test given is a multiple choice test totaling 30 questions. With levels of ability C4 to C6. The multiple choice questions were given to students during the pre-test and post-test in the experimental class and control class. Science learning outcomes data can be seen from the accuracy and completeness of students in answering these questions.

b. Non Test Instruments

The non-test instruments used in this study were interviews and observations. Interviews were conducted at the time of preliminary research to obtain data that would be used as the background for future research implementation. Meanwhile, observations were made to determine learning activities during STEM practice using observation sheets in the experimental class.

2.3 Procedure

There are several stages in this research procedure, including the preparation stage, the stage implementation and data processing stage. Following are the steps from these stages :

1. Preparatory Stages

a. The researcher makes a preliminary research permit which will be submitted to the school
b. The researcher conducted preliminary research to obtain information about the condition of the school, the number of classes, and the number of students who would be used as research subjects, as well as to obtain information about the activities of educators in class in ongoing learning activities.
c. The researcher determined two groups of research subjects to be used as the experimental class and the non-experimental class
d. The researcher compiled a Learning Implementation Plan (RPP) for the experimental class and the control class
e. Researchers compiled research grids and instruments to collect data in the form of multiple choice tests
f. Researchers conducted instrument trials
g. Researchers analyzed data from the results of instrument trials to determine whether the instruments compiled were valid and reliable or not

2. Implementation Stages

a. Researchers carry out pre-test in the experimental class and control class
b. Researchers carry out learning activities. The experimental class was given STEM treatment, while the control class was given treatment without STEM implementation.
c. Carry out a post test in the experimental class and control class

3. Final Stage

a. Collect, process and analyze science learning outcomes data on the pre-test and post-test
b. Compile a research report using statistics to look for differences in results in the experimental class and the control class.
c. Summing up the research results

2.4 Data collection technique

There are several stages in this research procedure, including the preparation stage, the stage implementation and data processing stage. Following are the steps from these stages :

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2.5 Data analysis

Data analysis techniques are used to get data into information so that the characteristics of the data are easy to understand. Before testing the hypothesis, it must first analyze the prerequisite test data.

1. Data Normality Test

The normality test was carried out to find out whether the data coming from the two classes in the form of learning outcomes came from populations that were normally distributed or not. The data normality test uses the Chi-Square formula x^2, according to Sugiyono (2018), namely:

$$x^2 = \sum \frac{(f_o - f_h)^2}{f_h}$$

Information:

x^2 = Chi – Squared / sample normality
f_0 = Observed frequency
f_h = Expected frequency
Source: Sugiyono (2018)

Comparing $x^2$the count with table values $x^2$with α = 0.05 and degrees of freedom (dk) = k-1, then consulted on *Chi Square* with the following test criteria:

If$x^2_{hitung} \leq x^2_{tabel}$ with α = 0.05 normally distributed, and

If $x^2_{hitung} > x^2_{tabel}$ then it is not normally distributed

2. Homogeneity Test Homogeneity test is carried out to see whether the data obtained has a homogeneous variance or not. The homogeneity test used is *Fisher's test* or also called F-test at a significant level α = 0.05. The formula is as follows:

$$F = \frac{\text{Varians Terbesar}}{\text{Varians Terkecil}}$$

Source: Arikunto (2014:228)

The results of the scores F_{hitung} are then compared with F_{tabel} the following decision-making criteria:

If $F_{hitung} < F_{tabel}$, then Ho is accepted, it means that the data variant is homogeneous

If $F_{hitung} > F_{tabel}$, then Ho is accepted, it means that the data variance is not homogeneous

3. STEM Practice Activity Data Analysis

the Science, Technology, Engineering, and Mathematics (STEM) approach is obtained by measuring through observation sheets during STEM practical activities. The results of the observation sheets related to activities in carrying out STEM practices will then be analyzed using the following formula:

$Ns = \frac{R}{SM} x\ 100$

Information:
Ns = Value
R = Total score obtained
SM = Maximum Score

Table 1 . STEM Practice Activity Value Categories

No.	Level of success	Information
1.	≥ 80	Very active
2.	60-79	Active
3.	50-59	Enough
4.	<50	Not enough

1. Normal Test (*N-Gain*)

N-Gain Test conducted to determine the level of success of students after certain treatment in research. The method used is to calculate the difference between *the pre-test* and *post-test* of the experimental class and the control class. The *N-Gain* formula is as follows:

$$N\text{-}Gain = \frac{\text{skor } post\ test - \text{skor } pre\ test}{\text{skor ideal} - \text{skor } pre\ test}$$

The criteria for the *N-Gain test* can be seen in the following table:

Table 2. Category Level of Problem Difficulty

***N-Gain* Value**	**Criteria**
N-Gain > 0.7	High Criteria
0.3 ≤ *N-Gain* >0.7	Moderate Criteria
N-Gain < 0.3	Low Criteria

Source: Hake (in Fatimah 2020)

The influence of the STEM approach can be seen how big or small the effect is. According to Naga (2005: 2), the magnitude of *the effect size* is the difference in the mean expressed in standard deviation, with the formula:

$d = \frac{\bar{x}_1 - \bar{x}_2}{s}$

with

$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_1^2}{n_1 + n_2 - 2}}$

Information:

d = Effect Size

$\bar{x}_1$ = Average of the experimental class

$\bar{x}_2$ = Average control class

n_1 = Number of experimental class samples

n_2 = Number of control class samples

s_1^2 = Variance of the experimental class

s_2^2 = Variance of control class

Table 1. Coefficient Criteria

Coefficient	**Criteria**
0 <d ≤ 0.2	Small Effect
0.2 <d ≤ 0.8	Moderate Effect
d > 0.8	Big Effect

Source: Dragon (2005:3)

2. Research Hypothesis Test using Simple Linear Regression and t test. Simple Linear Regression is a regression that has one independent variable (X) and a dependent variable (Y). This simple regression analysis aims to examine the effect of variable X on variable Y. Meanwhile, the t test is used to test whether there is a difference in the dependent variable (Y) with the treatment of the independent variable (X) and without any treatment.

1. Simple Regression Test

Hypothesis testing using a simple regression formula with statistical hypotheses as follows:

$\hat{Y} = \alpha + bX$

Technically to find the formula a and b ie

$a = \frac{\sum Y - b\sum X}{n}$

$b = \frac{n\sum XY - (\sum X)(\sum Y)}{n\sum X^2 - (\sum X)^2}$

Information:

$\hat{Y}$ = Dependent variable

X = Independent variable
α = Price constant value Y if X = 0
b = The value of the direction as a determinant of the forecast (prediction) which shows the value of increasing (+) or decreasing (-) variable Y
n = Number of data
Muncarno (2017:63)
Hypothesis Formulation:
Ha: There is an influence of the application of the *Science, Technology, Engineering and Mathematics* (STEM) approach to the science learning outcomes of students in grade V SD.
Ho: There is no effect of applying the *Science, Technology, Engineering and Mathematics* (STEM) approach to the science learning outcomes of students in grade V

2. T test

The t test is used to test whether there are differences in the learning outcomes of students in the experimental class using the STEM approach and the control class using the scientific approach, so the t test is used as follows

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2} \cdot \frac{1}{n_1} + \frac{1}{n_2}}}$$

Information:
t = $_{calculated}$ *t value*
$\bar{X}_1$ = Average of the experimental sample
$\bar{X}_2$ = Average control sample
n $_1$ = Number of experimental samples
n $_2$ = Number of control samples
s_1^2 = Standard deviation of the experimental sample
s_2^2 = Standard deviation of the control sample
Muncarno (2017:63)
Based on the above formula, a significance level of 5% or 0.05 is set, so the decision rule is $t$arithmetic ≤ $t$table, then Ha is rejected, whereas if $t$arithmetic.

III. Results and Discussion

3.1 Results

The results of the analysis in the experimental fifth grade class A showed different values before and after applying the STEM approach to the PjBL model. Before being given treatment, the average pre-test score for science learning outcomes in fifth grade class A was still low. After being treated by applying the STEM approach, the post-test average score for science learning outcomes for the experimental fifth grade class A increased compared to the pretest, so that it is known that there is an increase in the average value of the ability to learn science. Whereas in the control class the average value of the pre-test for science learning outcomes in fifth grade class B is higher than the pre-test value for the experimental class after being treated by applying a scientific approach with the PjBL model, the post-test average score for science learning outcomes in the control class fifth grade B not greater than the post ttest value of the experimental class, so it can be seen that there is an increase in the

average value of the ability to learn science in the experimental class is greater than the control class.

Based on the results of the analysis of test scores (pre-test and post-test) in the experimental fifth grade class A and control class B, it can be seen that the increase in pretest and post-test scores in the experimental class is greater than the increase in pretest and post-test control class. By implementing the PjBL integrated STEM approach to the experimental class with learning steps according to Khairiyah (2019: 94) consisting of reflection, research, discovery, application, and communication., the results will be different from the control class which uses a scientific approach to the PjBL learning model. In the experimental class, student activity during STEM practice in class A was included in the very active category.

The results of the normality test stated that the pre-test and post-test results of science learning outcomes in the experimental class ttable, then Ha is rejected, whereas if tarithmetic ≥ t table, Ha is accepted. If Ha is accepted, it means that there is a significant influence, so the researcher formulates the hypothesis as follows.

Ho: There is no positive and significant difference in the STEM approach in the experimental class compared to the scientific approach in the control class on the science learning outcomes of fifth grade students at elementary school

Ha : There is a positive and significant difference in the STEM approach in the experimental class compared to the scientific approach in the control class on the science learning outcomes of fifth grade students at elementary school were normally distributed.

Whereas in the control class it was stated that the pre-test and post-test results of learning outcomes in the control class were stated to be normally distributed with the acquisition of values in the pre-test obtained. Then the results of the homogeneity test on the pre-test data and post-test learning outcomes in the experimental class obtained a homogeneous variance. The results of the homogeneity test analysis on the post-test data and post-test learning outcomes in the control class obtained data that is homogeneous with the acquisition that is Fcount <Ftable.

The increase in the effectiveness of N-Gain after the application of the STEM approach to the experimental class has a moderate category, while the increase in the effectiveness of N-Gain in the control class by applying the Scientific approach has a low category, so it can be concluded that the use of the STEM approach has a higher success rate compared to the scientific approach. The effect size calculation obtained the value of the difference between the experimental class and the control class with a large category, so there is a difference between the experimental class after being given STEM treatment with the PjBL model in the experimental class is greater than the effect of the scientific approach with the PjBL model.

Increasing students' natural science learning outcomes through the application of the STEM approach can occur due to several factors, one of which is that the STEM approach is considered to be able to improve students' ability to solve problems through increased activity during the learning process. This is in line with the opinion According to Fatmawati, et al (2015: 42) The STEM approach is able to make students become problem solvers, confident inventors, innovators, aware of technology and able to think logically. Meanwhile, according to Astuti et al (2021: 79-89) Students who are accustomed to integrating problems with the STEM approach can help students think critically, logically and systematically. So it can be concluded that the application of the STEM approach can improve students' science learning outcomes through positive responses and increased activity during the learning process so that students can be critical in thinking and solving problems.

Testing the hypothesis in this study uses a simple linear regression formula and t test, based on simple linear regression calculations it can be concluded that there is an influence of the Science, Technology, Engineering and Mathematics (STEM) approach on the learning

outcomes of students in class V elementary school, and based on calculations using the test t it can be concluded that there is a positive and significant difference in the STEM approach in the experimental class compared to the scientific approach in the control class on the science learning outcomes of fifth grade students at elementary school.

So that it can be concluded from the research results that there is a significant influence in the implementation of learning using the STEM approach and there are positive and significant differences in the STEM approach in the experimental class compared to the scientific approach in the control class on the science learning outcomes of students in class V elementary school. The influence of the STEM approach with the PjBL model can be seen when there are learning activities using technology that has been applied to learning activities, increasing students' science learning outcomes, learning activities that are student-centered, and students being active in learning activities. Thus learning activities by applying the STEM approach with the PjBL model are aligned with the objectives of the STEM approach according to Jauhariyyah, et al (2018: 433), namely:

a. So that students can develop cognitive (knowledge), affective (attitude), and psychomotor (skills).
b. Students can identify questions and problems about STEM encountered and then make conclusions.
c. Form awareness of STEM disciplines that create intellectual intelligence and human culture.
d. Be a caring, constructive, reflective citizen in using STEM knowledge

As for the steps in the STEM approach. STEM according to Fathurrohman (2015: 236)namely project determination preparation of project implementation schedules, completion of projects with educator facilities and monitoring, preparation of reports and presentations, and evaluation of project processes and results.

In contrast to the control class which applies a scientific approach to the PjBL model, there is a significant difference due to the scientific approach using technology when learning activities have not been implemented so that students are less active in learning activities.

3.2 Evaluation

This research also has some limitations. Limitations in this study include:

1. The researcher only examined one factor that had the influence of the STEM approach on science learning outcomes as an alternative to choosing a learning approach which was considered very appropriate to be applied to the learning process. Even though theoretically there are many other factors that influence the improvement of students' learning outcomes
2. Research conducted by researchers has limited time, researchers conduct face-to-face learning for 6 days, namely 3 days in the control class and 3 times in the experimental class.
3. The population in this study was only in class fifth grade students at elementary school, so the research results would be different when applied to other schools

IV. Conclusion

Based on the results of the research and discussion, it can be concluded that there is an influence of the Science, Technology, Engineering and Mathematics (STEM) approach to the science learning outcomes of students in fifth grade class A, and there are positive and significant differences in the STEM approach in the experimental class compared to the

scientific approach in the control class on the science learning outcomes of class fifth grade students at state elementary school 2 wonodadi

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