



STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS) APPROACHES USING THEMATIC LEARNING MEDIA TO DEVELOP CRITICAL THINKING

Azka Falaih Rizqiyana¹, Cris Ayu Setyaningsih², Nurmita Sari³

¹²³Universitas Muhammadiyah Pringsewu, Lampung, INDONESIA

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ABSTRACT

Current learning emphasizes the integration of science and technology to face the challenges of the 21st century. Elementary school students experience difficulties in developing critical thinking skills due to the limitations of thematic learning media and appropriate learning approaches. Teachers must support the learning process following the changing times, namely integrating Science, Technology, Engineering, and Mathematics (STEM) into fun learning. The purpose of this study was to determine the effectiveness of the approach of using thematic learning media in developing the critical thinking skills of elementary school students. This research is a quantitative research using a quasi-experimental method with one-group-pre-test-post-test, which is to see the difference between the pre-test and post-test with 1 class without a control class. Furthermore, the data obtained in this study were in the form of students' answers to data collection instruments that measured students' critical thinking skills before and after treatment with the approach of STEM using thematic learning media. Based on the results of data analysis and discussion, it is concluded that the criteria for improving students' critical thinking skills are in the moderate category; there is a difference in the mean critical thinking skills between the pre-test group, namely before and the post-test group, namely after learning with the approach of STEM using thematic learning media and the post-test group, that is, after learning with the approach of STEM using thematic learning media has average critical thinking skills better than the pre-test group, namely before learning with the approach of STEM using thematic learning media.

Keywords: STEM, Learning Media, Thematic, Critical Thinking

INTRODUCTION

Current learning emphasizes the integration of science and technology to face the challenges of the 21st century. Therefore, teachers must prepare the next generation who have qualified human resources in the field of science and technology, so that learning is directed at the development of science and technology. The capability in science and engineering has also become the major focus of education studies in various countries because labor with this ability is needed [2].

Teachers must support the learning process following the changing times, namely integrating Science, Technology, Engineering, and Mathematics (STEM) into fun learning. STEM in learning is an approach that integrates several fields of science that are related to one another. Science requires mathematics as a tool in processing data, while technology and engineering are applications of science [1].

However, several international studies show that students' science and mathematics achievement, especially in developing countries, is still low. The results of the last Trends in International Mathematics and Science Study (TIMSS) which was held in 2015 for elementary school students showed that there were 16 out of 53 countries that obtained science achievement scores below the international average. Meanwhile, for mathematics achievement, there are 18 out of 54 countries with scores below the international average of 500 [8]. Not much different, the results

of the Program for International Student Assessment the 2015(PISA) study on science achievement also showed that there were 40 out of 72 countries that had scores below the international average (493), while for mathematics achievement there were 36 out of 72 countries that has a score below the international average of 490 [14].

The achievements of Indonesian students in the fields of science and mathematics are also quite concerning. TIMSS 2015 shows that Indonesia is ranked 50th out of the total participating countries for both fields with an including TIMSS and PISA requires higher thinking skills (order HOTS), including critical thinking skills, while the current learning process still lingering on Lower Order Thinking Skills [15].

Thus teachers are required to make innovations in learning to improve student achievement through increasing critical thinking skills. Critical thinking is one of the skills necessary to deal with the industrial revolution 4.0, because critical thinking is done to answer the question of "how" and the "why" using the principles and concepts [3]. These thinking skills allow students to analyze and draw conclusions independently. If a person fails to think independently, he will imitate others, adopt beliefs, and accept other people's conclusions passively [5]. Therefore, these thinking skills must be taught and instilled from an early age, starting with basic education.

In this regard, learning media is needed that can attract students' attention and interest in learning because according to Piaget's theory of cognitive development, children at the age of primary school (7-11 years) are included in the concrete operational stage which requires the help of real objects to learn so that can interact directly with the environment as a learning experience [12]. Therefore, the use of media for elementary school students is very important and necessary in the learning process. The teacher as a facilitator has a role to provide thematic learning media under Permendikbud Number 65 of 2013 that learning at the primary school level accommodates integrated thematic learning.

STEM stands for Science Technology Engineering & Mathematics. Kelley & Knowles explains that STEM is an approach to teach two or more subjects STEM with authentic practice to increase student learning motivation [7]. Sanders also argues that STEM is a learning approach that explores two or more subjects STEM and one or more subjects in schools [9]. Learning with the approach STEM can train students to apply the knowledge learned in school with phenomena that occur in the real world [2]. As explained by the National Research Council, through learning STEM students have the opportunity to learn science, mathematics, and engineering by solving problems that have real-world applications [13].

Correlated with the development of science and technology in elementary school students, learning media that can stimulate and attract students' interest are needed, namely thematic learning media for elementary school students. This is because learning in elementary schools in the 2013 curriculum uses integrated thematic learning, which consists of themes and sub-themes which are an amalgamation of several subjects. Permendikbud Number 65 of 2013, it states that learning at the primary school level accommodates integrated thematic learning, integration across subjects, across aspects of learning, and cultural diversity. Thus the learning resources used by the teacher to facilitate learning must also be thematic.

Currently, learning activities that take place in elementary schools tend to focus on lower-order thinking [14], while education that is following future needs can only be realized if students can develop higher-order thinking skills. One of the things that cause students to have low thinking skills is that the learning process that has taken place so far has not been able to develop these thinking skills. Many components greatly influence the learning process in schools, including content standards and process standards. The learning process in schools is of course inseparable from content standards and educational process standards because both are used as teacher guidelines in implementing the learning process.

The existence of content standards and the implementation of appropriate process standards in education units are expected to improve the quality of graduates which in turn can improve the quality of education. Content standards can be used as a reference in making learning media that can train students' thinking skills, while process standards are used as guidelines in designing and implementing a series of learning activities, including determining a learning approach that suits student needs.

One of the important elements in the learning process is the learning media. Therefore, teachers are expected to be able to develop teaching materials following school conditions, student backgrounds, and characteristics of the material to be taught. For example, in a theme that is related to science learning, a learning approach that is often carried out by teachers is teaching science concepts in the form of a collection of definitions or formulas. As a result, students tend to be less skilled in answering questions that are open and require higher-order thinking skills.

One of the efforts to overcome these difficulties is to develop a learning approach using appropriate learning media. If the learning material to be delivered is abstract, the learning media must be able to help students describe something abstract. Thus, it is necessary to research the learning approach STEM using thematic learning media in developing the critical thinking skills of elementary school students.

MATERIAL AND METHODS

Methods

This research conducted at SD Negeri 1 Sukoyoso Pringsewu. Research subjects were the fifth-grade students of SD Negeri 1 Sukoyoso Pringsewu, Lampung. This research is a quantitative study using a quasi-experimental method with a one-group-pre-test-post-test design, which sees the difference between the pre-test and post-test conducted in 1 class without a control class.



Figure 1. Design of Experimental Research

Description:

O1 = Pre-test

X = Treatment (Independent Variable)

O2 = Post-test [11]

In the current COVID19 pandemic situation, this research still uses offline learning. SD Negeri 1 Sukoyoso did not allow online learning to be held because not all parents can afford and have technology that supports online learning.

Instrument

The instrument used in this study was a test, consisting of a pre-test and a post-test. The pre-test instrument was intended to obtain preliminary data of students' ability before given treatment. Meanwhile, the post-test instrument was an instrument that was given after students received treatment. The test used was a written test in the form of multiple choices.

Procedures

The stages of this research consisting of:

- 1) The stage of preliminary study, this correlated to literature studies: Content Standards (KI, KD), Process Standards, Relevant research on the approach STEM and thematic learning media and critical thinking skills, Field studies: Learning approach, need for thematic learning media, critical thinking skills of students through observation and interviews
- 2) The stage of Designing and manufacturing, namely designing learning procedures with STEM approach integrated with the preparation of learning tools, research instruments, and learning evaluation tools, designing instructional media designs thematic learning media used, Making thematic learning media according to the concept and design
- 3) The stage of implementation and publication, namely Comparing Critical Thinking Skills between learning with the STEM approach using thematic learning media, Publications in accredited national journals, and producing in a national seminar

Data Analysis

The test instrument of critical thinking ability that was tried out consisted of 30 multiple choice questions with 4 alternative answer choices. The test instrument represents each indicator in theme 3, namely figures and findings, sub-theme 1, namely the inventor who changed the world. The test trials were carried out in grade V at SD Negeri 1 Sukoyoso Pringsewu Lampung, which was given to 30 respondents. The test instrument was tried out to determine the content validity and reliability of the test items.

The increasing score between pre-test and post-test show an increasing score in students' critical thinking skills. The increasing score was calculated based on the comparison gain of normalized or N-gain (g) using the Hake formula [4], namely:

$$\langle g \rangle = \frac{(\% \text{ post-test} - \% \text{ pre-test})}{(100 - \% \text{ pre-test})}$$

Description:

$\langle g \rangle$ = average normalized gain = average N-gain

$\% \text{ post-test}$ = post-test class percentage averages = average post-test percentage

$\% \text{ pre-test}$ = pre-test class percentage averages = average percentage of pre-test

The N-gain criterion is "low" if ≤ 0.3 ; "Medium" if $0.3 < \text{N-gain} \leq 0.7$; and "high" if the N-gain > 0.7 [4].

Hypothesis testing was done by testing the similarity and difference between two means, previously a prerequisite test was conducted in the form of a normality test and a test for the similarity of two variances (homogeneity) of data.

RESULTS AND DISCUSSION

Pre-test and post-test were given to measure students' ability to think critically before and after learning using the STEM approach with thematic learning media. Before the instrument was distributed, it was first tested for content validity and reliability as follows.

Content validity includes aspects of construction and aspects of language. The content validity test was conducted by two validators, namely Yunni Arnida, M.Pd and Rahma Faelasofi, M.Sc, as lecturers in the PGSD study program. After the content validity test was carried out by the validator, all items were declared valid because they met the criteria given. The predefined items were then tested for reliability. By using the KR-20 formula, the value of $r_{obtained} = 0.89$. Because $r_{11} = 0.89 > 0.70$, the test instrument was said to be reliable.

The results of the pre-test and post-test were used as data to test the effectiveness of this study. This value is first tested for normality and homogeneity.

a. Population Normality

The normality test was carried out on each data population, the data on the critical thinking ability of the pre-test and post-test students learning with the approach STEM using thematic learning media. The following is a summary of the data normality test for each population using the Liliefors Method with a significance level of 5%.

Table. Summary of Data Normality Results of Students' Critical Thinking Ability Pre-test and Post-test with STEM Approach using Thematic Learning Media

Group of Treatment	L_{obs}	$L_{(0,05;n)}$	Test of Decision	Conclusion
Pre-test	0,1317	0,1730	H_0 accepted	Normally Distributed
Post-test	0,1515	0,1730	H_0 accepted	Normally Distributed

Based on the normality test summarized in the table above, it can be seen that L_{obs} for each population less than $L_{(0,05;n)}$, meaning that the critical area $DF = \{ L \mid L > L_{(0,05;n)} \}$ then $L_{obs} < DF$. Thus it can be concluded that the samples from the pre-test and post-test treatment groups came from populations that were normally distributed.

b. Homogeneity Test of Population Variance The

Homogeneity test aims to determine whether the population has the same variance. In the homogeneity test of the two groups, namely the pre-test group and the post-test group carried out learning with the approach STEM using thematic learning media used the F-test. Based on the results of the calculation of the homogeneity test of population variance obtained $F_{obs} = 0,315$ and $F_{0,05;24,24} = 1,98$. That is, with the critical area of $DF = \{ F \mid F > F_{(n_1-1, n_2-1)} \} = \{ F \mid F > 1,98 \}$ then $F_{obs} < DF$. Thus the decision of the test is H_0 is accepted and concluded that the student population among the students in the group pre-test and post-test group performed learning approach STEM using thematic learning media has a homogeneous population variance.

c. Hypothesis Testing

1) Two-party t-test

The t-test is used to determine whether there is a difference in the average critical thinking skills of the pre-test group and the post-test group where learning is carried out using the approach STEM using thematic learning

media. Based on the results of the two-party t-test calculation obtained $t_{obs} = 5,210$ and $t(0,025;24) = 2,064$, meaning that the critical area $DF = \{t \mid t > 2,064\}$ then $t_{obs} \in DF$. Thus the test decision is H_1 accepted and it is concluded that there is a difference in the mean critical thinking skills between the pre-test group and the post-test group where learning is carried out using the approach STEM using thematic learning media.

2) one-party t-test

The t-test is used to determine which group has better average critical thinking skills between the pre-test and post-test groups. Learning is done by the approach of STEM using thematic learning media. Based on the results of the one-party t-test calculation, it is obtained $t_{obs} = 5,210$ and $t(0,05;24) = 1,711$, meaning that with the critical area $DF = \{t \mid t > 1,711\}$ then $t_{obs} \in DF$. Thus the test decision is H_1 accepted and it is concluded that the post-test group carried out learning with the approach STEM using thematic learning media has an average critical thinking skill that is better than the pre-test group carried out learning with the approach STEM using thematic learning media

DISCUSSION

Based on data analysis carried out with one-party t-test, it was obtained $t_{obs} = 5,210$ and $t(0,05;24) = 1,711$, meaning that with the critical area $DF = \{t \mid t > 1,711\}$ then $t_{obs} \in DF$. Thus the test decision is H_1 accepted and it is concluded that the post-test group carried out learning with the approach STEM using thematic learning media had an average critical thinking skill better than the pre-test group carried out learning with the approach STEM using thematic learning media. Then based on the N-gain calculation, it was found that the N-gain score was 0.4 so that it was included in the criteria for moderate improvement.

The increase in the average critical thinking skills of students is due to the STEM approach being able to challenge and motivate students in practicing critical thinking skills, analysis, and improving higher-order thinking skills. The STEM approach trains students to have a different way of thinking than usual and develop critical power in forming logical thinking, so this approach can be applied in various sciences. Besides, students will get used to solving problems well. STEM-based education will form human resources who are capable of reasoning and thinking critically, logically, and systematically. [6].

In connection with the development of science and technology in elementary school students, learning media that can stimulate and attract students' interest are needed, namely thematic learning media for elementary school students. This is because learning in elementary schools in the 2013 curriculum uses integrated thematic learning, which consists of themes and sub-themes which are an amalgamation of several subjects. Following Permendikbud Number 65 of 2013, it states that learning at the primary school level accommodates integrated thematic learning, integration across subjects, across aspects of learning, and cultural diversity.

For this reason, learning with the approach of STEM using thematic learning media makes it easy for students to understand the concept of a theme that does combine various interrelated subjects. With this understanding of the concept, students can analyze the problems given by the teacher using their thoughts so that they can make choices and draw conclusions intelligently. In this case, students' critical thinking skills improve.

The results of this study are in line with the research conducted by Novidya STEM (Science, Technology, Engineering, and Mathematics) learning for students can expand their knowledge to cover more concepts or/and science shortly, can improve student learning outcomes and responsive to solving problems requires a critical and effective way of thinking [9]. The learning process includes the process of interpretation, analysis, evaluation, concluding, and explaining according to the realm of knowledge who can think critically. STEM learning that can be felt in real life, and can increase the logical logic of a problem. Then students can analyze events, data, and phenomena and relate to existing theories. After that, evaluate and conclude what has been learned and convey the information

CONCLUSION

Based on the results of data analysis and discussion, the following conclusions are obtained. The criterion for improving students' critical thinking skills is the medium category. There is a difference in the mean critical thinking skills between the pre-test group, namely before and the post-test group, namely after learning with the approach STEM using thematic learning media. The post-test group, that is, after learning with the approach stem using thematic learning media has an average critical thinking skill better than the pre-test group, namely before learning with the approach STEM using thematic learning media.

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