# Implementation of science technology engineering and mathematics approach in learning to critical thinking skills of fifth-grade elementary school students in Lampung Province

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## Abstract

Critical thinking skills is an important aspect of the learning process in the 21st-century era. It can be improved with the Science, Technology, Engineering, and Mathematics (STEM) approach in learning. This study aims to analyze the implementation of the STEM approach in learning to the critical thinking skills of fifth-grade elementary school students in the province of Lampung. The benefits of this research are (1) being able to improve students' critical thinking skills through the STEM approach, (2) the integration of the four aspects of the STEM approach can create active, innovative, and logical thinking students, (3) as a renewal and innovation in learning so that learning is oriented to students, and (4) the STEM approach can

be used as an input for learning in elementary school. This study uses a quasi-experimental design with experimental and non-experimental classes. The population of this study amounted to 311 students and the research sample amounted to 59 students. The data is obtained using a test in the form of an essay which consist of 6 questions. Items measure critical thinking skills with six indicators, namely focus, reason, inference, situation, clarity, and overview. The reliability of the items in the high category (0.65) and the validity of the items in the moderate to very high category (0.44-0.95). The difference in the test results of the experimental class is 68.695 and the non-experimental class is 61.250. Data analysis using Kolmogorov Smirnov with the largest | FT-FS | t-test < table value of 0.111 < 0.246. The results show that the critical thinking skills is significantly higher in the experimental class students than in the non-experimental class. The results of the research on the critical thinking skills of fifth-grade elementary school students in Lampung Province are influence by the STEM approach with a significance level of 0.111 (sig <5%). Implementation of STEM approach in learning plays an important role in improving the critical thinking skills of fifth-grade students.

**Keywords**: critical thinking skills, elementary school, learning, STEM approach.

# Introduction

21st-century skills in the world of education are skills that must be mastered by every student and even become essential to the progress of education in Indonesia. These skills are being able to think critically and problem-solving, learning and innovating skills, collaboration, communicating effectively, analyzing information, and having life skills (Widana et al., 2018; Wijaya et al., 2016; Zubaidah, 2016). Various skills are pursued by all elements of education so that students can compete with other countries and are ready to face life's challenges (Astutik & Hariyati, 2021; Nuryanti et al., 2018). Students in elementary schools need to be supported to have 21st-century skills such as critical thinking skills.

Critical thinking skills play an important role in today's life aspects (Erikson & Erikson, 2019; Halpern, 2014; Prajapati et al., 2017). Every problem that students encounter will be easily overcome if they can think critically. Critical thinking skills is a person's ability to think that is fundamental, reasonable, and reflective which includes activities to analyze, synthesize, create, identify questions, and be able to make logical conclusions and characterize 21st-century learning (Asyari et al., 2016; Butterworth & Thwaites, 2013; Ennis, 2011; Mahanal et al., 2019; Mardliyah, 2018; Schmaltz et al., 2017). Critical thinking skills are also part of the mental process that teaches how to understand the events and conditions of environment as well as to acquire new knowledges (Doleck et al., 2017; Zubaidah et al., 2018). Students with critical thinking skills looked different compared to others since their curiousity is high. Critical thinking skills are actually required for students to conceptualize themselves being active, skilled, easy to solve problems, able to collect data and make hypotheses, and applying all their learned knowledges (Changwong et al., 2018; Cintamulya, 2019).

Having critical thinking skills, the students can transfer knowledge from one domain to another. Furthermore, the educators teach them how these abilities can develop efficiently and contribute to every field (Zohar et al., 1994). The effectiveness of a person's critical thinking skills needs an indicator to determine the achievement of a predetermined target. There are six indicators of critical thinking skills i.e., Focus, Reason, Inference, Situation, Clarity, Overview (FRISCO) (Ennis, 2011). The six indicators of critical thinking skills provide a broad and useful range of knowledge for students. So, by the six indicators, they are expected to be a reference in measuring students' critical thinking skills.

In fact, the conditions that occur in elementary schools today are that the students have low critical thinking skills. This problem is appeared because the learning activity is still oriented to educators as the center of attention (teacher centered mode). So far, educators have not been able to handle it properly. However, it is already known that critical thinking skills have become a curriculum demand in elementary schools to prepare the students dealing with complex life (Rachmadtullah, 2015; Septikasari & Frasandy, 2018; Sukmana, 2018).

The integration STEM approach into Project Based Learning (PjBL) can be applied to overcome the low critical thinking skills of fifth-grade elementary school students in Lampung Province. Knowledge learned through the STEM approach is most useful in the daily lives of students and gives different meanings in its implementation (Ritz & Fan, 2014). The STEM approach is a learning approach that integrates knowledge of STEM in a student-centered learning environment and teach the student how to investigate engineering-related problems and find solutions and then build evidence-based on explanations relating to real-world phenomena (Changpetch & Seechaliao, 2020; Crotty et al., 2017; Shernoff et al., 2017).

The implementation of the STEM approach is the best way to learn in elementary schools to improve children's critical thinking skills (Yaki et al., 2019). This is because the STEM approach can foster active, meaningful, and creative learning where the four scientific aspects are simultaneously acquire to solve daily life problems. The implementation of learning is under the steps of the STEM approach which consists of reflection, research, discovery, application, communication (Khairiyah, 2019). The STEM approach can create quality learning in student-centered schools so that the output produced is under the learning objectives.

In addition, STEM also implemented in developed countries such as USA has a real impact on the development of students to be active, innovative, creative, productive, and excelling in schools (Kocakaya & Ensari, 2018; Oktapiani & Hamdu, 2020; Permanasari, 2016; Wang & Chiang, 2020). Furthermore, students who get learning with the STEM approach will form a sense of confidence to always contribute to the development of technological literacy (Prismasari et al., 2019; Salar, 2021). The purpose of the STEM approach in learning in elementary schools is to develop cognitive, affective, psychomotor skills and to form awareness of STEM disciplines that create intellectual intelligence and human culture (Haryanti & Suwarma, 2018; Jauhariyyah et al., 2017).

Learning with the STEM approach can be applied to mathematics subjects. Mathematics has an important role in the growth of children's critical thinking skills through learning activities (Hidayati, 2017). The benefits obtained from learning mathematics are that it can form a systematic, logical, critical, and careful mathematical mindset (Acar et al., 2018; Azizah et al., 2018; Karso et al., 2010). When students learn mathematics, they also learn how to construct their thoughts. Based on this, students need to be trained to think highly, namely critical thinking.

The previous research on critical thinking skills, such as the research by (Putranta et al., 2019) shows a difference with our research which lies in the use of PhET simulations to improve critical thinking skills. The results of increasing students' critical thinking skills are obtained an average N-gain value of 0.61 (medium category). In addition, research by (Parno et al., 2021) shows that 7E LC and STEM-Based 7E LC models significantly affect the improvement of participants' critical thinking skills. Furthermore, research by (Selisne et al., 2019) shows that using modules with the STEM approach effectively increases student competence consisting of knowledge, attitudes, and skills. This study aims to determine the implementation of the STEM approach to the critical thinking skills of fifth-grade elementary school students in Lampung Province.

# Methods

The type of research used is experimental research. Experimental research is that researchers deliberately make experimental research and there are controls and conditions regulated by researchers (Triyono, 2013). The research method used is a quasi-experimental design (Sugiyono, 2015). The variables contained in this study consisted of two independent variables (STEM approach) and the dependent variable (critical thinking skills).

The fifth-grade of Tri Sukses Natar elementary school is selected as experimental and non-experimental classes. The experimental class (n = 29 students) uses the STEM approach, while the non-experimental class (n = 30 students) doesn’t use the STEM approach. Then, the experimental and non-experimental classes is assessed and compared to see the cause and effect and its effect on the variables given the treatment. Critical thinking skills data is measured using a test instrument. The test refers to an indicator of critical thinking skills known as FRISCO (Davies & Barnett, 2015; Ennis, 2011).

Based on the indicators of critical thinking skills, the authors made six test questions in the form of essays to measure the critical thinking skills of fifth-grade students. The questions are made according to the indicators of critical thinking skills which consist of FRISCO. Previously, the author perform the instrument test on 22 students at Gedong Air 1 elementary school who have the same criteria as the students of elementary school where the main research is conducted. The six questions is declared valid and reliable with the acquisition of r count > r table. Test the validity of the test instrument using the product moment correlation formula, while the reliability test using the Cronbach Alpha formula (Fraenkel et al., 2012).

It is adjusted to the four aspects of STEM i.e., science, technology, engineering, and mathematics (Guleryuz & Dilber, 2021). Aspects of science are focus learning on shape of objects and force of gravity of the earth which is associated with the subject matter of building cubes and blocks. The students learning outcomes for this aspect are students know and understand that a cube and block is an example of a solid object. The technological aspect is to direct students to apply the knowledge gained into a skill using hardware such as laptops and smartphones to get information that will be useful for designing a product to be produced. This is raised in learning by showing videos about building cubes and blocks using an LCD/projector and laptop.

Following the next aspect is engineering used to trained students to be able in processing and to solve existing problems such as how to design products accurately on it size (Shahali et al., 2017). For example, students make a dice design with the concept of building a cube space and make a pencil box design with the concept of a unit cube. When carrying out engineering aspects in learning, students can indirectly construct their thoughts in designing a project related to their life and also create creativity and improve critical thinking skills. The last for mathematical aspect, student is directed to gain the basic competencies and indicators in learning achievement of fifth-grade that is to analyze the elements of building blocks and cubes. The results are that students become easier to understand the learning of building cubes and blocks, seem more fun by making a project and think logically (Han et al., 2016).

Based on those aspects, the authors started to give pre-test before implementing the STEM approach. So that, the authors treat STEM to the students and at the end of the lesson the authors give a post test to see the results of the STEM approach treatment (Sugiyono, 2015) (see table 1).

**Table 1.** The procedure of a quasi-experimental design.

| | | |
|---|---|---|
| O1 | X1 | O2 |
| O3 | X2 | O4 |

Note:

O1 = Pre-test value in the experimental class,
O2 = Post-test value in the experimental class,
O3 = Pre-test value in the non-experimental class,
O4 = Post-test value in the non-experimental class,
X1 = Treatment using the STEM approach,
X2 = Treatment without using the STEM approach.

Then the normality test is calculated using the following Kolmogorov Smirnov formula (Razali & Wah, 2011).

# Results and Discussion

The results of the measurement of the average value of the pre-test and post-test results of students' critical thinking skills in the experimental class and non-experimental class can be seen in Table 2.

**Table 2.** Average pre-test and post-test results for the experimental class and the non-experimental class.

| No | Aspect description | Experimental | | Non-experimental | |
|---|---|---|---|---|---|
| | | Pre-test | Post-test | Pre-test | Post-test |
| 1 | Number of students | 29 | 29 | 30 | 30 |
| 2 | Total value | 1904.174 | 2000.08 | 1712.510 | 1837.511 |
| 3 | Averages | 65.661 | 68.965 | 57.084 | 61.250 |

Table 2 shows that the average post-test result of the experimental class's critical thinking skills after applying the STEM approach is greater than the average result of the non-experimental class pre-test. The determination of experimental and non-experimental classes is not based on high and low scores on pre test. But it determine those classes have the characteristics of students with the same age in learning needs and same level. In addition, this research focuses on how much the increase in the value given by the STEM approach to those who are not given the STEM approach in classroom learning. Furthermore, when it implements in the experimental class the average value becomes larger. It is clear that there is an increase in the value in both classes (experimental and non-experimental). Eventhough the range of non-experimental is higher than experimental value (post test - pre test), it doesn’t mean that the non-experimental students have a good critical thinking skills than the student experimental class. In consequence of the beginning of starting values in pre test. In addition, it depends on actual situation that happened during the research field. If depicted in the graph, the average results of critical thinking skills are shown in Figure 1. The bar chart of the average pre test and post test results for the experimental and non-experimental classes can be seen in Figure 1.

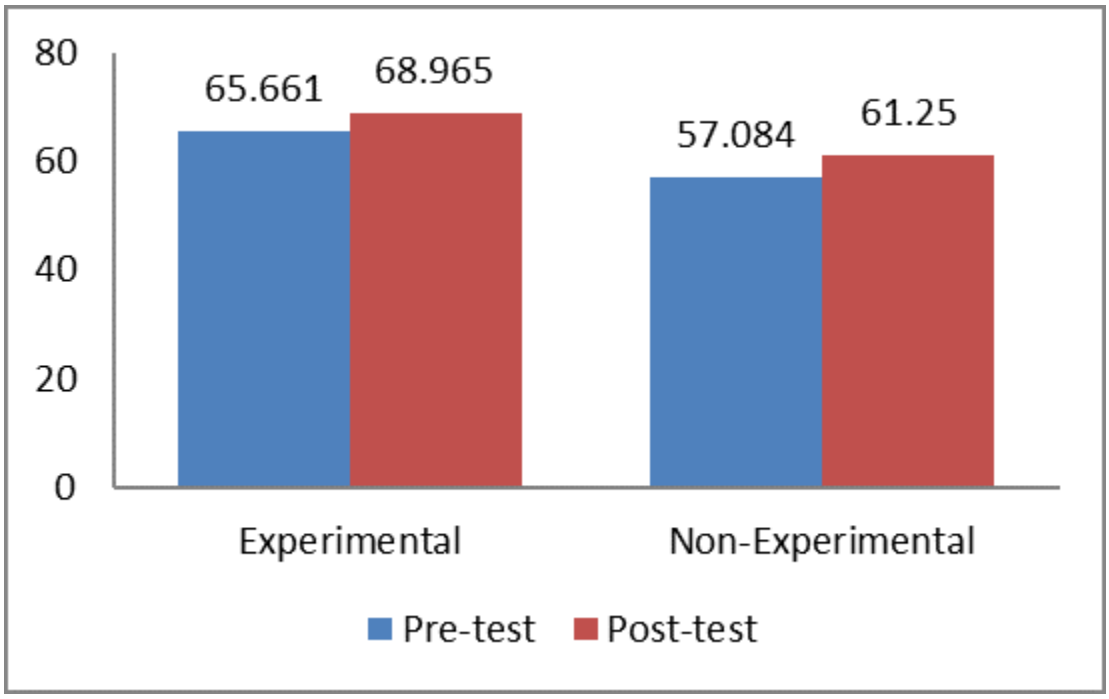


**Figure 1.** Bar chart of the average pre-test and post-test scores for the experimental and non-experimental classes.

Students who apply the STEM approach can form an awareness of STEM disciplines that create intellectual intelligence and human culture, so that what students learn at school is easier to absorb (Capraro et al., 2013). Meanwhile, students who did not receive the STEM approach were less able to construct their thoughts, especially in mathematics. This can be seen in the examples of students' answers in the experimental and non-experimental classes shown in Figures 2 and 3.

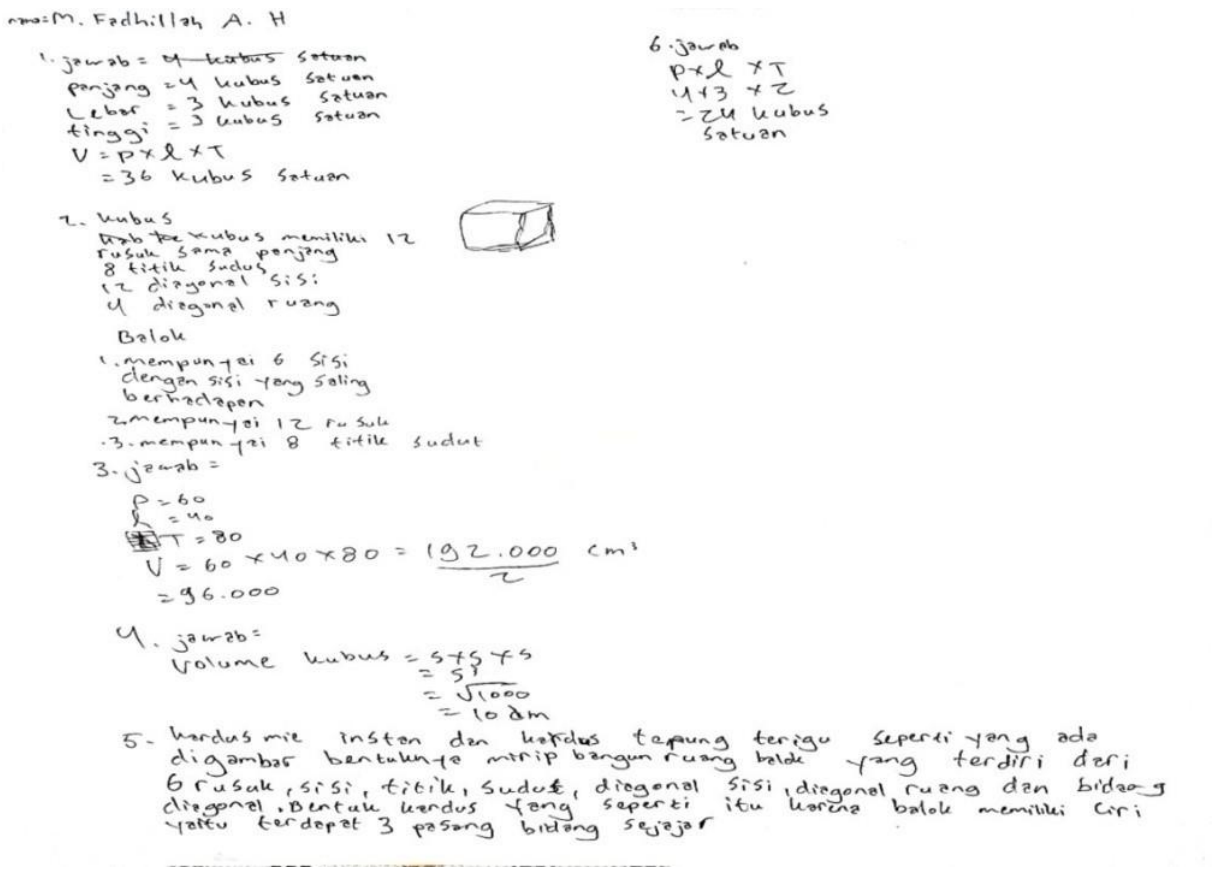


**Figure 2.** Examples of students' answers in the experimental class.

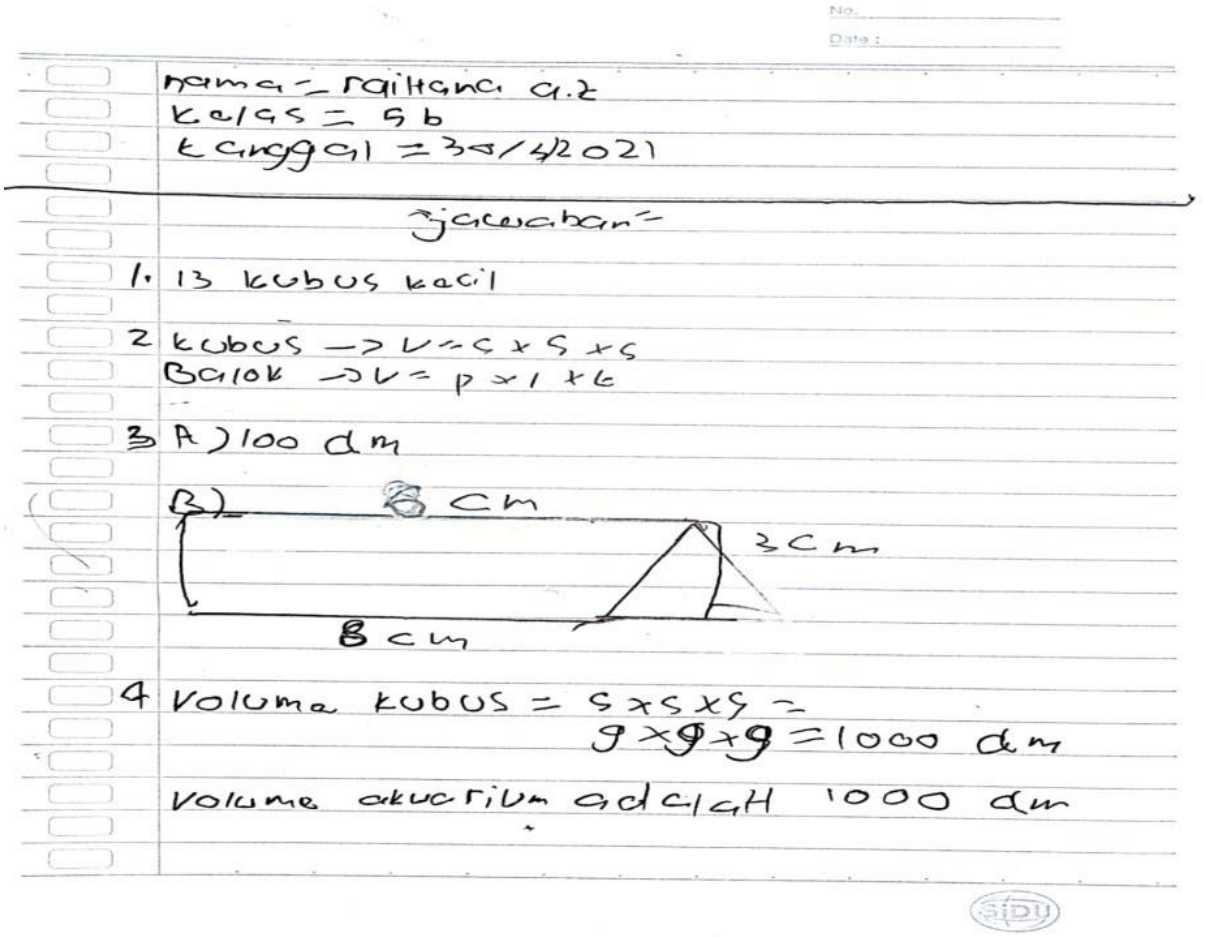


**Figure 3.** Examples of students' answers in the non-experimental class.

Based on the examples of students' answers between the experimental and non-experimental classes, there are differences, including (1) experimental class students are better at answering the questions given; (2) experimental class students gave detailed answers than the non-experimental class; and (3) experimental class students better understand the questions given than the non-experimental class. These differences indicate that the experimental class students meet the criteria for critical thinking skills. This is relevant to similar research on critical thinking skills by other researchers, namely (Afriana et al., 2016) and (Lestari, 2020).

Normality test is useful to find out whether a data is normally distributed or not. The data tested for normality consisted of initial and final data from the results of the experimental and non-experimental critical thinking skills. Normality test using *Kolmogorov Smirnov* with probability $\alpha = 0.05$. The results of the analysis of the normality test on the pre-test data obtained a table value of 0.246. So that the largest $|FT - FS| <$ table value ($0.160 < 0.246$) means that the pre-

test data on critical thinking skills of the experimental class is normally distributed (see Table 3).

**Table 3.** The results of the normality test (pre-test) of critical thinking skills

| No | *Xi* | *F* | *F kum* | *Fs(x)* | *Mean* | *Deviasi Standar* | *Z* | *Ft(x)* | *Fs(x)-Ft(x)* | *\| Fs(x)-Ft(x)\|* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 45.5 | 3 | 3 | 0.103 | 65.661 | 15.050 | -1.339 | 0.090 | 0.013 | 0.013 |
| 2 | 55.5 | 8 | 11 | 0.379 | 65.661 | 15.050 | -0.675 | 0.249 | 0.130 | 0.130 |
| 3 | 65.5 | 8 | 19 | 0.655 | 65.661 | 15.050 | -0.012 | 0.495 | 0.160 | 0.160 |
| 4 | 75.5 | 5 | 24 | 0.827 | 65.661 | 15.050 | 0.653 | 0.743 | 0.084 | 0.084 |
| 5 | 85.5 | 3 | 27 | 0.931 | 65.661 | 15.050 | 1.318 | 0.906 | 0.025 | 0.025 |
| 6 | 95.5 | 2 | 29 | 1.000 | 65.661 | 15.050 | 1.982 | 0.976 | 0.024 | 0.024 |

The results of the analysis of the normality test to the post-test data obtained a table value of 0.246. So that the largest $|FT - FS| <$ table value ($0.111 < 0.246$) means that the final observation data (post-test) of the experimental class's critical thinking skills is normally distributed (see Table 4).

**Table 4.** The results of the normality test (post-test) of critical thinking skills.

| No | *Xi* | *F* | *F kum* | *Fs(x)* | *Mean* | *Deviasi Standar* | *Z* | *Ft(x)* | *Fs(x)-Ft(x)* | *\| Fs(x)-Ft(x)\|* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 45.5 | 4 | 4 | 0.103 | 68.966 | 14.502 | -1.618 | 0.052 | 0.085 | 0.085 |
| 2 | 55.5 | 3 | 7 | 0.379 | 68.966 | 14.502 | -0.928 | 0.176 | 0.064 | 0.064 |
| 3 | 65.5 | 8 | 15 | 0.655 | 68.966 | 14.502 | -0.239 | 0.405 | 0.111 | 0.111 |
| 4 | 75.5 | 7 | 22 | 0.827 | 68.966 | 14.502 | 0.450 | 0.673 | 0.084 | 0.084 |
| 5 | 85.5 | 5 | 27 | 0.931 | 68.966 | 14.502 | 1.140 | 0.872 | 0.058 | 0.058 |
| 6 | 95.5 | 2 | 29 | 1.000 | 68.966 | 14.502 | 1.829 | 0.966 | 0.033 | 0.033 |

Hypothesis testing is done by using rtable. If rcounts > rtable with $\alpha = 0.05$ then Ha is accepted, and if rcounts > rtable then Ha is rejected. It was found that rcounts 0.685 with N = 29 for = 0.05 obtained rtable 0.367; so that are rcounts > rtable (0.685 > 0.367) and the hypothesis is accepted.

The average post-test score of students after applying learning with the STEM approach was higher than the pre-test score. The implementation of learning with a STEM approach can improve students' critical thinking skills in elementary schools and provide meaningful experiences for their lives in the future (Davidi et al., 2021). In addition, learning with the STEM approach taught in elementary schools can have a positive impact on children's development, one of which is the result of creativity by making various crafts as a result of learning the STEM approach in the form of a pencil box by applying the concept of building cubes and blocks as shown in Figure 4.

**Figure 4.** The results of students' work through STEM approach learning.

Through the STEM approach, students will automatically form a collaborative spirit and creativity in the learning process that integrates four disciplines of STEM to think critically and solve problems (Falentina et al., 2018). The benefits obtained by applying learning with the STEM approach in elementary schools are that it can support the skills of students in the 21st-century through the learning process, students are able to solve problems well, and can improve students' critical thinking skills through project-based digital literacy (Maula & Fatmawati, 2020).

The hallmark of learning with the STEM approach is that students are required to be actively involved in the learning process and require students to be able to integrate various STEM knowledge which then constructs their thinking so that they can think critically (Han et al., 2015; Sasmita & Hartoyo, 2020). The STEM approach needs to be taught through concrete and contextual things. Because the level of thinking elementary school age students has not been

able to think abstractly. The four aspects of STEM in learning are able to improve critical thinking skills. The achievement of increasing critical thinking skills is due to a predetermined indicator. The indicator consists of six i.e., focus, reason, inference, situation, clarity, and overview (FRISCO) which is manifested in the form of pre-test and post-test questions. Where *F* (focus) is to introduce students to what should be discussed and identify problems. Furthermore, students need to provide rationally supporting reasons for the existing problems, this is part of the *R* (reason). *I* (inference) is the process of making conclusions based on appropriate arguments that investigated and evidence that has been obtained. *S* (situation) defined as belief in thinking process and making decision that supported by physical and social environment. Where *C* (clarity) is to convey the message to the decisions made. And the last indicator is *O* (overview) is to review and verify the problems that have been found previously. Those indicators are used to measure the extent of students' critical thinking skills and their resulting product with STEM approach as shown in Figure 4.

Students in the experimental class show higher pre test and post test scores, while the non-experimental class without STEM is actually growing but still lower in scores. Then the findings show that the STEM approach has been good associated to critical thinking skills. In addition, it has been proved that it can increase students' critical thinking skills as a part of 21st-century skills.

The STEM approach globally is a necessity and required by the world of education today, especially to increase students critical thinking skills of elementary schools. This approach direct students to involve, to motivated and to have a positive impact on their lives in acquiring knowledge since they are learning at a young age to support their future achievements (Lee et al., 2019; Taylor, 2018; Thibaut et al., 2018; Trúchly et al., 2019). Based on finding of this research and the results of a systematic review of the existing literature. This research is contributed to solve the learning problem in the 21st-century by implementing and providing a clear definition of the framework of the STEM approach in learning with the critical thinking skills of fifth grade elementary school students. The framework of this research has beneficial for learning implementation with student-oriented in elementary schools, which are the students become more active and innovative. However, further research is recommended to know the implementation of the STEM approach to other 21st-century skills i.e., creativity, collaboration, and problem solving.

The increase in students' critical thinking skills indicates the success of the application of the integrated project-based learning (PjBL) STEM approach. This needs to be maintained through a learning process in which educators must be able to foster students to work independently, creatively, innovatively against the various challenges of life. The STEM approach taught in schools provides a learning innovation for the world of education that aims to develop students' critical thinking patterns (Ulfa et al., 2019). Although there are some short comings in the implementation of learning, for example, educators are not familiar with the STEM approach. The advantages are that students are more enthusiastic about learning, active, and creative.

# Conclusion

The skills to think critically has an important role to improve the way students thinking which aims to develop the perspective of collecting various information obtained during learning process. It is an essential need of every student in the 21st-century in order to achieve superior education. The problem that occurs today is the low critical thinking skills of students in elementary schools. The solution that can be made to improve students' critical thinking skills in elementary schools are implementing the STEM approach in learning. Because through the STEM in the classroom the learning become more active, creative, joyful, and meaningful.

In brief, this research concluded that the STEM approach in learning influence the critical thinking skills of fifth-grade students in Lampung Province. The results show that there is a significant effect between learning by the STEM approach on critical thinking skills, it prove that the average final result of critical thinking skills of students in the experimental class is greater than the non-experimental class. The experimental class (68.695) and the non-experimental class (61.250). The data analyze using Kolmogorov Smirnov with the largest $|FT-FS|$ t test < table value of 0.111 < 0.246. The students who have been given the STEM approach in learning more careful and detail in understanding and answering the questions than students who do not receive the STEM approach. The implication is the students critical thinking skills are increased by the STEM approach involved in learning.

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