The impacts of science, technology, engineering, and mathematics (STEM) on critical thinking in elementary school

Yulia Elfrida Yanty Siregar1*, Reza Rachmadtullah2, Nirwana Pohan3, Rasmitadilla4 and Zulela MS1

1State University of Jakarta, Indonesia
2University of PGRI Adi Buana, Surabaya, Indonesia
3State Elementary School 49 in Banda Aceh, Indonesia
4Djuanda University, Bogor, Indonesia

*yulyasiregar@gmail.com

Abstract: In line with the development of the world paradigm on the meaning of education, education is faced with a number of challenges, namely that education should be able to produce human resources who have complete competence. This competence relates to science, technology, engineering, and mathematics which is also known as STEM. The focus on STEM is education and work. Unfortunately, students in elementary schools in mathematics and science are not used to training in critical thinking. The results of this study indicate (1) the impact of STEM can improve students' critical thinking in elementary schools, (2) the importance of STEM education, and (3) STEM as an alternative that can improve students' critical thinking skills.

1. Introduction

Based on the results of the PISA (survey Program for International Student Assessment) in 2015 aimed at measuring the achievements of literacy, mathematics, and science literacy. The biggest increase was seen in science competency, from 382 points in 2012 to 403 points in 2015. Mathematical competence increased from 375 points in 2012, to 386 points in 2015. Mathematical literacy and science are one's ability to formulate, work on, and interpret mathematical and scientific matters in various contexts. This includes reasoning and the use of concepts, procedures, facts, and tools to describe, explain, and predict a phenomenon [1]. In recent years there has been a lot of increased attention given to science, technology, engineering, and mathematics in various fields of research and practice, which are packaged as abbreviated terms STEM. Although all four of these disciplines have been bound together under the same umbrella, there is no consensus about the extent to which they relate to some stating that they are a separate knowledge base [2]. The definition of STEM education, (1) teaches between / between two or more STEM disciplines or (2) teaches any STEM discipline that is integrated with other school subjects designed to prepare students to be equipped with the knowledge and skills to solve complex real-world problems [3].
2. Perspectives on STEM Education
One of the definitions of STEM education that appears very appropriate in highlighting the mathematics and science disciplines in STEM space is STEM education refers to problem solving that draws concepts and procedures from mathematics and science while combining teamwork and designing technical methodologies and using the right technology. However, there is still debate and confusion about what involves STEM education [4], on whether discipline must be integrated and to what extent [5], and even on whether the acronym itself must continue to be used [6]. Work in the context of a complex phenomenon or situation on a task that requires students to use their knowledge and skills from different disciplines [7]. Some arguments are offered for the benefits of STEM integration including as a means to add meaning and connect students to learning throughout the STEM discipline, its relevance to address real-world problems and the increasing use of multidisciplinary teams in many professions [8].

It is often said that many general approaches to STEM education in schools do not reflect the natural way in which discipline is connected in the real world [9]. In implementing the STEM program, ensure that each discipline is developed adequately. produce problems to reason, design and actually apply lessons that meet the objectives of each field of learning.

3. Methods
Purpose of this study is to describe whether STEM education can improve students' critical thinking skills in elementary school. As for the problem in this study the implementation of STEM Education, especially for Class V elementary school students in Aceh. And are there any differences in the results of students' critical thinking skills before and after learning by using STEM ?. This research method uses action research that aims to improve the quality of learning, especially in elementary schools. As for the subject of this study were 120 students consisting of several elementary schools in Baiturrahman District, Aceh Province. Before conducting research, researchers first observed as a pre-research activity to diagnose an important problem. From the results of the Pre-Research activities the critical thinking skills of students must be increased.

After analyzing the characteristics of students, the steps are taken to analyze the curriculum. The activity of analyzing the curriculum is a strategy of learning activities or scenarios that must be done so that learning objectives can be achieved effectively and efficiently. At this stage of curriculum analysis, researchers develop Basic Competencies arranged into indicators, the indicators compiled are formulated into learning steps. The process of curriculum analysis starting from developing basic competencies is organized into indicators of learning, learning indicators are prepared by learning steps, then developing tests of critical thinking skills using STEM.

4. Result and Discussion
The first step, students are given a pretest before being given treatment using STEM in fifth grade students in elementary school. Given with the usual learning the teacher does in class. After the learning activity process is carried out, students are given evaluation test questions, where students are asked to answer several questions on the questions provided. Based on the results of the pretest conducted by 120 research respondents, namely grade V elementary school students who obtained an average score of 6.61.

After knowing the initial ability of students by knowing the results of the pretest obtained, the teacher and researchers prepared preparation for Posttest, atstage Posttest this students were given an explanation and understanding of the steps of learning using STEM. The results of the Posttest obtained a value of 7.61. Based on that identified the results of the pretest and posttest can be known using the two-average difference test (t-test) described in the following statistical calculations:
Table 1. Pretest and posttest results

| Paired Samples Statistics | Mean | N   | Std. Deviation | Std. Error Mean |
|----------------------------|------|-----|----------------|-----------------|
| Pair 1                     |      |     |                |                 |
| Pretets                   | 6.61 | 120 | .783           | .163            |
| Postets                   | 7.61 | 120 | .891           | .186            |

| Paired Samples Correlations | N   | Correlation | Sig. |
|----------------------------|-----|-------------|------|
| Pair 1                     | 120 | .487        | .018 |

| Paired Sample Test          | Mean | Std. Deviation | T    | df  | Sig. (2-tailed) |
|-----------------------------|------|----------------|------|-----|-----------------|
|                             | .853 | .178,63        | 5.624| 22  | 1.000           |

Based on the calculations in Table *Paired Samples Statistics* looks average critical thinking skills test before using STEM by 6.61 and a standard deviation of 0.783 and after using STEM 7.61 with a standard deviation of 0.891. This means that descriptively there are differences in the average test of critical thinking skills before and after using STEM. In the table *Paired Sample Correlations*, a correlation coefficient of critical thinking ability test scores was obtained before and after being given learning using STEM of 0.487 with sig numbers or p-value = 0.018 ≥ 0.05 or significant. In the table *Paired Sample Test*, obtained the difference mean = 1.000 which means that the students' critical thinking ability test scores after and before using STEM are completed. Positive positive prices after being given STEM learning critical thinking test scores are higher than before given STEM learning. Then in this table also obtained a standard error the mean that shows the standard error rate of the average difference. Furthermore, the most important result of this table is the price statistic alt = -5.624 with db = 22 and a significant number. or p-value 0.000 < 0.05 or H0 is rejected. Thus it can be concluded that there are significant differences in critical thinking ability tests between before using STEM learning.

The results of this study were also strengthened by research others. The focus of activities then becomes one of learning or making ideas [9], not just the application of routine procedures or problem-solving strategies [10]. In problem solving of course students are required to think critically involving "rational assessment and sharpness of the elements of reasoning and different from memorizing memorization or remembering simple information, methods to encourage critical thinking have the purpose of stimulating the analytical and evaluative processes of the mind" [11]. The lack of students' critical thinking skills results from students' negative attitudes towards these abilities, and the lack of qualified teachers and curriculum abstractions from everyday life [12].

Individuals also learn scientific concepts and acquire problem solving skills by involving engineering designs [13]. In addition, this situation will increase individual motivation in the lesson and draw their attention to the subject. In addition, STEM education is also considered important for the development of student decision-making skills [14].

Learning uses STEM, placing students at the center of their learning where they are encouraged to engage with meaningful but challenging problem situations that can lead to the application of higher levels of cognitive reasoning [15]. STEM provides a meaningful, practical, active and authentic shared learning experience [16]. STEM often contains abstract concepts [17], which require an understanding
of the theoretical nature beyond what students can manipulate at a practical level [18]. In addition to STEM learning focused on students [19]. Future directions need to include teacher professional development where the framework implemented for integrated STEM education and related curriculum resources is available [20].

5. Conclusion

Based on these results it can be concluded that (1) there are differences in the results of students' critical thinking skills before and after learning by using STEM. (2) the critical thinking skills of class students have increased. The overall score and scores of students are able to achieve the target of the success indicators set by the teacher 75% of all students are fulfilled, namely from 55.81% to 86.42%. This means an increase in grade V students around 30.61%. (3) Learning using STEM in this study can improve students' critical thinking skills in grade V in elementary school.

References

[1] Peña-López, Ismael. "PISA 2012 Assessment and Analytical Framework. Mathematics, Reading, Science, Problem Solving and Financial Literacy." (2012).65.
[2] Bell, Randy L., and Norman G. Lederman. "Understandings of the nature of science and decision making on science and technology based issues." Science education 87.3 (2003): 352-377..
[3] Basham, James D., and Matthew T. Marino. "Introduction to the topical issue: Shaping STEM education for all students." Journal of Special Education Technology 25.3 (2010).1.
[4] Shaughnessy, J. Michael. "Mathematics in a STEM context." Mathematics Teaching in the Middle school 18.6 (2013): 324-324.
[5] Bybee, Rodger W. The case for STEM education: Challenges and opportunities. NSTA press, 2013.
[6] Williams, John. "STEM education: Proceed with caution." Design and Technology Education: An International Journal 16.1 (2011). 26–35.
[7] Honey, Margaret, Greg Pearson, and Heidi Schweingruber, eds. STEM integration in K-12 education: Status, prospects, and an agenda for research. Washington, DC: National Academies Press, 2014.
[8] Stohlmann, Micah, Tamara J. Moore, and Gillian H. Roehrig. "Considerations for teaching integrated STEM education." Journal of Pre-College Engineering Education Research (J-PEER) 2.1 (2012): 4., 28–34.
[9] Moore, Tamara J., et al. "Implementation and integration of engineering in K-12 STEM education." Engineering in pre-college settings: Synthesizing research, policy, and practices. Purdue University Press, 2014.
[10] DiFrancesca, Daniell, Carrie Lee, and Ellen McIntyre. "Where Is the" E" in STEM for Young Children? Engineering Design Education in an Elementary Teacher Preparation Program." Issues in Teacher Education 23.1 (2014): 49-64.
[11] LIU, RD. "On the meaning and connotation of critical thinking." Teacher Education Research 1 (2000): 56-61.
[12] Pithers, RT, & Soden, R. (2000). Critical thinking in education: A review. Educational Research, 42 (3), 237-249.
[13] Bakırı, Hasan, and Dilek Karışan. "Investigating the Preservice Primary School, Mathematics and Science Teachers’ STEM Awareness." Journal of Education and Training Studies 6.1 (2017): 32-42.
[14] Kennedy, T. J., and M. R. L. Odell. "Engaging students in STEM education." Science Education International 25.3 (2014): 246-258.
[15] Hunter, Roberta, et al. "Innovative and powerful pedagogical practices in mathematics education," Research in Mathematics Education in Australasia 2012-2015. Springer, Singapore, 2016. 213-234..
[16] Maistry, S. M. "School-university CPD partnerships: Fertile ground for cultivating teacher communities of practice." *South African Journal of Higher Education* 22.2 (2008): 363-374.

[17] Brigham, Frederick J., Thomas E. Scruggs, and Margo A. Mastropieri. "Science education and students with learning disabilities." *Learning Disabilities Research & Practice* 26.4 (2011): 223-232.

[18] Witzel, Bradley S., Cecil D. Mercer, and M. David Miller. "Teaching algebra to students with learning difficulties: An investigation of an explicit instruction model." *Learning Disabilities Research & Practice* 18.2 (2003): 121-131.

[19] Moore, Tamara J., et al. "Implementation and integration of engineering in K-12 STEM education." *Engineering in pre-college settings: Synthesizing research, policy, and practices.* Purdue University Press, 2014.

[20] Nadelson, Louis S., et al. "i-STEM summer institute: An integrated approach to teacher professional development in STEM." *Journal of STEM Education: Innovation and Outreach*(2012).69–83.