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The Impact of STEM Acitivities on Computational Thinking Skills: A Case of Pre-Service Elementary School Teachers in Universitas Lampung

Loliyana*, Ismu Sukamto, Nelly Astuti, Maman Surahman
Department of Elementary School Teacher Education, Universitas Lampung, Indonesia

Abstract: The research purpose was to implement of the STEM 4.0 approach in improving student CT. This study used a quasi-experimental design with one group pretest - posttest design. The learning integrated 4 STEM components to improve students' CT. Participants were elementary school teacher education students at state universities in Lampung Province. The test instrument is at the cognitive level C4 and C6 which refers to Bloom's Taxonomy. Based on research data, it is stated that in learning with the STEM 4.0 approach, there are activities to understand the concept of learning material (Science) by integrating everyday life phenomena (Mathematics) and supported by learning media (Technology). Furthermore, there are learning activities in the form of practice activities in solving a problem in groups and making simple products by applying the concepts contained in the learning materials. Through this treatment, CT participants increased with male CT participants being higher than female.

Keywords: computational thinking, STEM approach, pre-service elementary school teacher.

Abstrak: *Tujuan dari penelitian ini adalah untuk mengimplementasikan pendekatan STEM 4.0 dalam meningkatkan CT siswa. Penelitian ini menggunakan desain eksperimen semu dengan one group pretest – posttest design. Pembelajaran mengintegrasikan 4 komponen STEM untuk meningkatkan CT siswa. Instrumen tes berada pada level kognitif C4 dan C6 mengacu pada Taksonomi Bloom. Berdasarkan data penelitian disebutkan bahwa dalam pembelajaran dengan pendekatan STEM 4.0 terdapat kegiatan memahami konsep materi pembelajaran (IPA) dengan mengintegrasikan fenomena kehidupan sehari-hari (Matematika) dan didukung oleh media pembelajaran (Teknologi). Selanjutnya terdapat kegiatan pembelajaran berupa kegiatan praktik dalam memecahkan suatu masalah secara berkelompok dan membuat produk sederhana dengan menerapkan konsep-konsep yang terdapat dalam materi pembelajaran. Melalui perlakuan ini, peserta CT meningkat dengan peserta CT laki-laki lebih tinggi daripada perempuan.*

Kata kunci: *Computational thinking, pendekatan STEM, calon guru Pendidikan sekolah dasar.*

▪ INTRODUCTION

Adaptive character is important to meet the needs of the 21st century community. Moreover, character strengthening is the government's concern in developing superior Human Resources (HR), especially at the tertiary level (Junaidi, 2020). One of the components needed to strengthen student character is Computational Thinking (CT). CT is a mental skill to apply fundamental concepts and reasoning, which comes from modern digital computers and computer science; in all fields, including activities in daily. CT becomes a conceptual tool for students to apply logical and algorithmic thinking in finding solutions to problems involving complex multidimensional systems (Berland & Wilensky, 2015; Lee & Malyn-Smith, 2020). Thus, CT involves solving problems, designing systems, and understanding human behavior, by presenting them in the basic concepts of computer science (Wing, 2006).

Loliyana
*Email: loli.yana@fkip.unila.ac.id

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So far, research on CT has only focused on concepts, practices, and perspectives (Román-González et al., 2017). There is a need for learning innovations to train CT students. Moreover, learning in the current digital era, especially due to the COVID-19 pandemic; conducted online which demands the independence of students. The innovation that is estimated to be right in today's digital era is to apply the STEM 4.0 Approach. It considers that there is a particular picture of CT from the side of a STEM-centered approach which not only views CT as connected with mathematics to collect and analyze data and test hypotheses in a productive and efficient way, but also as a centralized process of reasoning (Psycharis & Kallia, 2017; Schwarz et al., 2017; Weintrop et al., 2016). Although the STEM 4.0 Approach consists of 4 aspects, namely: Science, Technology, Engineering and Mathematics; however, these components are integrated in the implementation of learning. Thus, the STEM 4.0 approach facilitates students both individually and in groups to be able to understand certain concepts (Science) supported by Information and Communication Technology (ICT) (Technology)-based learning media that are important in online learning. Furthermore, activities in learning with a STEM approach can also increase collaboration and collaboration, especially in the simple product development process (Engineering). In addition, students can also learn to improve work effectiveness and efficiency of the resources used by converting concepts into mathematical formulations (Mathematics). However, educators need to note that there are challenges in applying the STEM approach, especially in developing a learning environment that allows students to use a scientific approach to explain complex phenomena and solve unstructured problems (Council, 2000; Krajcik & Blumenfeld, 2006).

The integration of these 4 STEM components is an important supporter in improving CT. Moreover, CT requires the use of heuristic reasoning to find solutions ranging from planning, learning, and scheduling in the presence of uncertainty (Wing, 2008). Through Engineering, students are actually trained to find solutions to design a simple product based on the concepts they have learned. In addition, Mathematics facilitates students to find the best step among the existing uncertainties. In the end, a simple product is produced as a form of creativity which is the highest cognitive level (Conklin, 2005). In addition, the integration of these four aspects also allows students to master the competencies needed to complete assignments and solve real-world problems (Wang et al., 2011). The findings of previous research indicate that there is a positive effect of STEM integration on the dimensions of computational thinking and self-confidence (Psycharis & Kotzampasaki, 2019). In addition, students on STEM outreach programs show a much higher understanding of the application of computer programming in everyday life (Feldhausen et al., 2018).

Based on the description that has been stated, the purpose of this study is to test the application of the STEM 4.0 approach in improving student CT. Therefore, the research question can be stated as follows.

1. How can the STEM 4.0 approach improve student CT in learning?
2. How is the increase in student CT after learning with the STEM approach?
3. How is student CT based on gender?

▪ METHOD

Research Design

This research is an experimental research (Quasi-Experimental Design) (Fraenkel et al., 2012). using a quantitative approach. Quantitative approach was used to determine the CT level of participants both before and after the treatment. Participants were divided into 2 experimental groups to be given learning with the STEM 4.0 approach for 8 meetings. More simply, the research design can be seen in Figure 3.1 below.

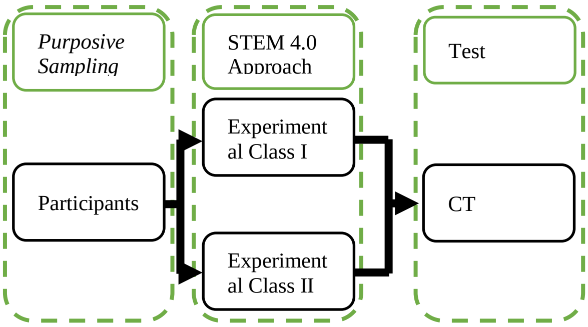

Fig. 1. Research design

Participants

Participants in this study were elementary school teacher education students at state universities in Lampung Province with a total of 44 people. The number of male students as many as 18 people and 26 women. Participants are currently studying in semester 6. Participants are divided into 2 groups, the first group is Experiment Class I with a total of 23 people and the second group is Experiment Class II with a total of 21 people. Participants were determined using purposive sampling technique.

Research Instruments and Procedures

The test instrument consists of 6 CT dimensions with each dimension represented by 2 indicators and 2 description questions. The 6 dimensions of the CT are 1) Decomposition; 2) Abstraction; 3) Algorithm Design; 4) Debugging; 5) Iteration; and 6) Generalization (Román-González et al., 2018; Shute et al., 2017). The instrument is at the cognitive level C4 (Analysis) and C6 (Creation) which refers to Bloom's Taxonomy (Conklin, 2005). Based on the results of the validity and reliability test, the instrument was declared valid with a score of 0.596, 0.533, 0.350, 0.613, 0.379 and 0.537 (greater than the value of rtable = 0.344 where N = 33). The instrument is also declared reliable with Cronbach's Alpha value of 0.739.

The application of the STEM 4.0 approach was carried out in Experimental Classes I and II with the same treatment. Specifically, students learn the concepts contained in the lecture material (Science) with the help of learning media (Technology). In the process of understanding these concepts, students operate numbers and reason to relate them to everyday life phenomena (Mathematics). By understanding these concepts, students design and develop simple tools (Engineering). Before and after the treatment, participants were given a CT test.

Data Analysis

Data analysis was carried out statistically with SPSS version 25. At the initial stage, the tests carried out were prerequisite tests, namely normality tests and homogeneity tests. Based on the test results, the pretest data was declared to be normally distributed with the value of Sig. of 0.084 in the Experimental Class I and 0.080 in the Experimental Class II (greater than 0.05) as presented in Table 1.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Factor	Statistic	df	Sig.	Statistic	df	Sig.
ExpClass	I	.151	23	.190	.925	23	.084
	II	.225	21	.007	.918	21	.080

a. Lilliefors Significance Correction

Tests were also carried out on posttest data. Based on the results of statistical tests, the posttest data was declared to be normally distributed with the value of Sig. of 0.867 in the Experimental Class I and 0.627 in the Experimental Class II (greater than 0.05) as presented in Table 2.

Table 2. Data of shapiro-wilk parametric analysis (posttest)

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Factor	Statistic	df	Sig.	Statistic	df	Sig.
ExpClass	I	.127	23	.200*	.978	23	.867
	II	.104	21	.200*	.965	21	.627

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Next, homogeneity test was carried out. Based on the results of statistical tests, it is stated that the two experimental classes have the same variance, are homogeneous; with the value of Sig. of 0.317 (Table 3), greater than 0.05.

Table 3. Data of test of homogeneity of variances

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
ExpClass	Based on Mean	1.026	1	42	.317
	Based on Median	1.062	1	42	.309
	Based on Median and with adjusted df	1.062	1	41.664	.309
	Based on trimmed mean	1.048	1	42	.312

Furthermore, based on the Stem-and-Leaf Plots Diagram; there are no outliers. Thus, the next statistical test can be performed.

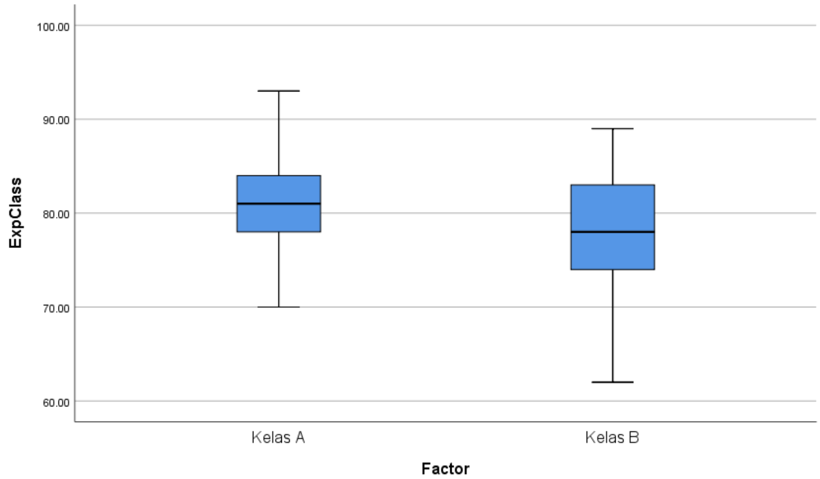

Figure 2. Stem-and-leaf plots of posttest in the class of experiment i and ii

After the prerequisites are met, the statistical test is continued with one way ANOVA test and paired samples test. One way ANOVA test was used to determine the consistency of the effectiveness of the STEM 4.0 approach on increasing CT participants in Experimental Classes I and II. Paired samples test was used to determine the increase in CT participants after being given treatment.

▪ RESULT AND DISSCUSSION

Based on the results of the One Way ANOVA test on the posttest data of Experimental Class I and II, Sig. (P-value) of 0.088 (greater than 0.05). This shows that there is no significant difference in the posttest mean value in the two experimental classes.

Table 4. The results of one way anova test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	130.445	1	130.445	3.051	.088
Within Groups	1795.441	42	42.749		
Total	1925.886	43			

Furthermore, based on the results of the Paired Samples Test; it is stated that there is a difference between before and after treatment with the value of Sig. (2-tailed) = 0.000 (Table 5), less than 0.05. Furthermore, the Mean value = 26.68 with a positive value was obtained. This means that there is a tendency to increase CT after treatment with an average of 26.68.

Table 5. The results of paired samples test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-26.68182	10.85373	1.63626	-29.98165	-23.38198	-16.307	43	.000

The posttest data in the two experimental groups were then grouped by gender. Overall, the mean CT scores for males were greater than the mean CT scores for females.

Table 6. Comparison of male and female CT average scores

No	Participants	Average Score of CT
1	Female	78.50
2	Male	80.78

In detail, male CT scores were higher than female on the dimensions of Abstraction, Iteration, Algorithm Design and Decomposition. In contrast, female CT scores were higher on the Debugging and Generalization dimensions than males.

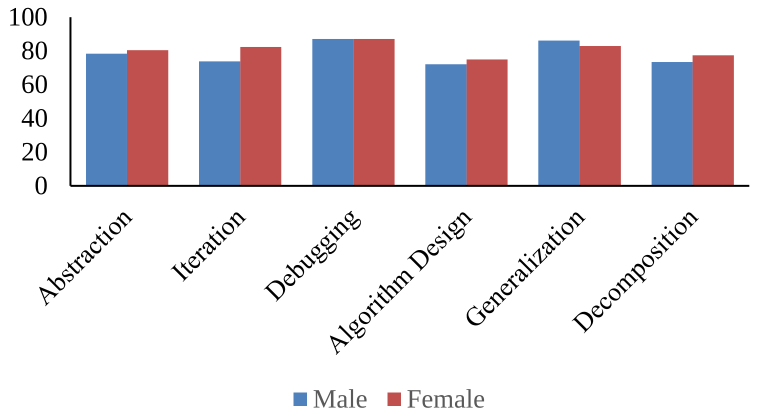

Figure 3. Comparison of male and female CT values in each dimension

The application of the STEM 4.0 approach was carried out in online learning in both experimental classes. In this online learning, participants are given material exposure to provide basic knowledge (Science). The material presentation is also integrated with everyday life phenomena, both from the experience of educators and from the participants themselves (Mathematics). During the presentation of the material, educators use learning media in the form of presentation materials, which contain text and images; and learning videos (Technology). Learning activities are also equipped with practice activities in solving a problem in groups. Furthermore, participants were given the task individually to make a simple product by applying the concepts contained in the learning materials.

Through the integration of everyday life phenomena, participants are trained to describe the problems contained in it (Decomposition). From the description of the problem, participants convert it into manageable steps to be studied theoretically so that a solution can be found (Abstraction). Theoretical studies refer to the concepts contained in learning outcomes. This is done so that participants understand the concept as well as apply it in problem solving. From these studies, the data analysis results are then simplified and presented into a problem solving scheme (Algorithm Design) so that a systematic solution can be designed (Debugging). This process is carried out on a hypothetical concept. This means that the solutions provided are only ideas that can be implemented.

However, participants also carry out activities that are applicable in designing solutions, namely making simple products. In the process of making this product, participants identify, analyze and implement the most productive and effective steps in order to produce the product based on the basic competencies that have been shared (Iteration). These steps include drawing on important concepts in the basic competencies that can be used for simple product development (Decomposition); determination of simple products that can be developed (Abstract); requirements analysis, including concepts, tools and materials used (Algorithm Design). In the end, participants can draw conclusions regarding the application of the concept of learning materials in solving problems that can be applied to other similar problems. In addition, participants also provide a model/procedure that is most effective and efficient in making simple products (Generalization). Therefore, there is an increase in CT participants after being given learning with the STEM 4.0 approach.

Based on gender, male CT participants were higher than female participants. Of the 6 CT dimensions, male participants had higher scores on 4 dimensions, namely: Decomposition, Abstraction, Algorithm Design and Iteration. While in the other 2 dimensions, female participants had a higher score.

▪ CONCLUSION

Based on the analysis of research data, it can be concluded that in learning with the STEM 4.0 approach, there are activities to understand the concept of learning material (Science) by integrating the phenomena of everyday life (Mathematics) and supported by learning media (Technology). Furthermore, there are learning activities in the form of practice activities in solving a problem in groups and making simple products by applying the concepts contained in the learning materials. Through this treatment, CT participants increased with male CT participants being higher than female.

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