Indonesian Journal of Learning and Instruction p-ISSN 2614-8250, e-ISSN 2614-5677
Volume 5, Issue 1, April 2022 https://journal.uniku.ac.id/index.php/IJLI

THE IMPLEMENTATION OF SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS (STEM) 5E TO OMPROVE STUDENTS' CREATIVITY AND PROBLEM-SOLVING SKILLS IN LEARNING THE HUMAN CIRCULATORY SYSTEM

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APA Citation: Septimawati, W., Hindriyana, A. F., & Sulistyono. (2022). The implementation of Science Technology Engineering and Mathematics (STEM) 5E to improve students' creativity and problem-solving skills in learning the human circulatory system. *Indonesian Journal of Learning and Instruction*, *5*(1), 9-16. doi: 10.25134/ijli.v5i1.5871.

Received: 11-01-2022 Accepted: 26-02-2022 Published: 30-04-2022

Abstract: This research was motivated by the low creativity of students and problem solving skills, only 10% showed indicators of creativity. The purpose of this research is to increase students' creativity and problem solving skills through the implementation of STEM 5E. Creativity and problem solving skills are important for students as provisions in the future. The population in this study were Middle School students. 8 at SMPN 1 Jalaksana, which is divided into two classes, namely the experimental class and the control class. The research design used is a nonequivalent control group design, the type of research is quasi-experimental. The experimental class uses STEM 5E learning, while the control class uses demonstration learning. The instruments used in this study were observation sheets, written tests of 15 description questions with three indicators of problem-solving ability, namely recognizing problems, finding problems, and provide solutions, and other data in the form of a questionnaire to determine student responses. The results of the study on the implementation of STEM 5E learning showed that the preliminary, core and closing activities were carried out well. The results of observations of student creativity showed that the average value of the experimental class was 71.58 while the control class was 28.97. The average result of the experimental class students' problem solving ability was 81.11, much higher than the control class at 40.79. With the implementation of STEM 5E experimental class students are better in terms of creativity and problem solving skills.
Keywords: *STEM 5E; creativity; ability to solve problems.*

INTRODUCTION

The learning process takes place in the interaction of several components to achieve learning objectives. The world of education is now facing global challenges including producing graduates who are ready to face international competition. These changing times demand that in addition to increasing students' knowledge, it can also be used in real life. High intelligence needs to be accompanied by creativity and problem solving skills.

Student creativity is a potential that will develop according to their life experiences. The potential for creativity that humans have from birth will be a provision in solving life's problems. This potential will develop according to his life experiences. Creativity is needed as a student's life provision to solve life's challenges.

Creativity leads students to solve problems, product models, in a domain in a way that was initially considered fictional (Gardner, 1993). Creativity is also an individual mental process that gives birth to effective new ideas, processes, methods or products. Another result of the creative process is a product that is imaginative, flexible, successional, and discontinuous, which is useful in various fields to solve various problems. Casing and Romble (2021) believed that dismal outcomes might result in a lack of creativity, stifling of innovation, and a fear of failure.

The development of creativity needs to be done from an early age, especially for a student. Munandar (2004) suggests that the strategy of developing student creativity can be carried out in four aspects, known as the four P's, namely person (personal), press (driver), process (process), product (product). Student creativity will develop if an environment is created that values responsible freedom. The family as the initial foundation is very important, but in learning the teacher is the second parent. Cho, Pemberton, & Ray (2017) stated that barriers to increasing creativity education were identified as a lack of educators' understanding of creativity, children's freedom of expression, curricular restrictions, and the high-stake testing environment.

Student creativity that has emerged will guide students in solving their cognition problems in learning. The ability to solve problems is part of life skills which are assessed as learning outcomes. details and distinctions that others miss. Thus, when generating and solving problems, the level of students' domain-general creative thinking has influenced their domain-specific creative thinking (Tan, 2020). The importance of problem-solving skills in learning is like fuel for a vehicle. Potential problem-solving abilities are unique to an individual. Teachers need to guide students to find this potential.

Students who have the ability to solve problems will be able to; capture the core of the problem, find facts about the problem. Another indicator is that students are able to interfere in providing alternative solutions, reducing or eliminating data appropriately. These abilities will all be needed by students in making generalizations as an effort to make conclusions.

Learning will be easy to achieve its goals, if students' creativity and problem-solving skills appear.

Science is closely related to everyday life, especially Biology which studies living things, including humans. The basis of Science Process Skills consists of skills to observe, classify, predict, measure, infer and communicate (Yamtinah, Masykuri, Ashadi, and Shidiq (2017). The development of Biology will develop rapidly, along with the rapid advancement of technology. Creativity and The ability to solve problems is certainly the basic potential that students must have in learning it.

The fact that happened in learning the concept of the human circulatory system in class VIII, out of 10 groups, only 1 or 2 groups showed indicators of creativity. Students in the two groups began to give ideas even though they were only in the imitating stage. The originality of the idea is not yet apparent. Most of the students did not dare to make hypotheses, let alone determine alternative solutions. This if left unchecked can make learning less memorable and concepts easy to forget for students, it is necessary to find solutions so that learning is interesting and meaningful for students.

The result of reflection from learning, one of the obstacles is the concept of the Human Circulatory System is difficult to see with the naked eye. Submission of this concept requires learning media, generally teachers use chart media. According to Usman (2002), Charta is a learning media in the form of two-dimensional visual images to get some information. The charta media has a weakness, namely students do not always know how to interpret images (Wiryawan, 1987). The fact that occurs when the teacher uses the circulatory system chart, students only interpret images based on the direction of the teacher, not yet growing their creativity. Students do not have the opportunity to develop ideas in making the design of the circulatory system when presented with a demonstration model.

Demonstration model is a way of presenting lessons by demonstrating or showing students a certain process, situation or object that is learned either in actual or in imitation which is often accompanied by an oral explanation (Djamarah & Zain, 2010). The demonstration model is generally used for fat classes such as in class VIII of SMPN 1 Jalaksana, if it only reaches students' cognition. The advantage of this model is that students will concentrate their concentration with the help of chart media, especially if it is supported by the ability of the teacher's lectures. Unfortunately, what happened in class VIII of SMPN 1 Jalaksana, students only studied theoretically. They are less aware of their creative potential and problem-solving abilities. Communication occurs in one direction even if there is only occasional communication between students and teachers. The bad thing is that students are less involved with learning media as a result creativity and problem-solving skills in students do not appear.

The right solution is to think of a learning model that involves students in making charts. Science or science as the basis of science becomes an inspiration to realize a problem around us. Technology as a tool to answer problems on the basis of science. This science and technology will be more appropriate if combined with engineering (engineering) or the technique of designing a project design, with mathematical calculations (Hills, 2019).

The combination of science, technology, engineering and mathematics is known as STEM. Initially STEM is a combination of four sciences in a learning. This learning model encourages student activities in the teaching and learning process, with the encouragement of student activities, students' science process skills will grow (Chayati, Masykuri, Utomo, 2020). STEM is a paradigm that creates inter-disciplinary learning and provides achievement results of science, mathematics, engineering, and technology while doing so (Nugroho, Pernamasari, & Firman, 2019). The development of STEM is in accordance with the rapid advancement of technology. However, the main challenge for teachers in teaching using STEM education is how to integrate science, engineering, technology and mathematics and see the interrelationships and interdependencies between the 4 sciences (Pradeep, 2015). Another challenge is how to help students realize that solutions to real-world problems involve using knowledge, processes and practices from these four disciplines. So we need a STEM-oriented learning model. Learning still involves mastering concepts that are connected to real problems in everyday life such as the Learning cycle. Wiguna, Suwarma, &Liliawati (2018) have conducted STEM-based science learning research by asking students to design balloon-powered cars as learning media in understanding the concept of regular straight motion and found that students become motivated and directly involved in the manufacturing process.

Learning cycle offers such a pedagogical approach in organized teaching by setting the purpose and use of lesson content at the beginning of the lesson with a real-life context, involving students actively in the learning process, providing opportunities to connect lesson content to real-life applications and making students have science experience as engineers do (Pradeep, 2015).

The learning cycle model is this learning that pays attention to the achievement of cognition in stages and cycles. The 5E learning cycle model with a STEM approach will better address design abilities that are unique to individuals. Teachers are expected to be able to help students to design a project. Even students will try to imitate, take advantage of technology gradually and cyclically. This learning model is known as STEM 5E. The 5E learning cycle model is the best known model and is expected to be effective if it is based on the STEM approach. The combination of the STEM approach in the 5E Learning cycle model is known as STEM 5E learning.

Based on the description above, STEM 5E learning is thought to be able to overcome the problem of students' lack of creativity and problem solving ability.

The aims of this study were 1) to analyze the implementation of STEM 5E learning on students' creativity and problem-solving abilities, 2) to analyze the increase in student creativity after implementing STEM 5E learning, 3) to analyze the improvement of students' problem solving abilities after implementing STEM 5E learning, 4) analyze student responses to STEM 5E learning

METHOD

The research design used in this study was quasi-experimental. The form of design used is a nonequivalent control group design, but students' creativity is not pretested. This design is almost the same as the non-pretest nonqiovalent control group design (Sugiyono, 2018) but the experimental group and the control group were not given a pretest first. The control group and the experimental group were not chosen randomly, the experimental group used the STEM 5E learning model, while the control group used demonstration learning as is usually done by teachers. The research was carried out at SMP Negeri 1 Jalaksana, as for the time of the research, which was in December 2020 s.d. April 2021.

Table 1. *Collecting data technique*

No	Technique	Instrument	Type of Data	Data Source
1	Observation	Observation Sheet	Assessment of the number of students showing creativity indicators is used to assess student creativity per indicator	Student
4.	Written Test	Essay test	Student answer scores for the problem-solving ability description test are used to determine students' problem-solving abilities	Student
2	Observation	Observation Sheet	Assessment of teacher activities in learning to see if the learning steps are in accordance with the actions desired by the teacher (the experimental class uses STEM 5E while the control class uses demonstrations)	Teachers and Students
3.	Questionnaire	Questionnaire sheet	The questionnaire sheet is used to see student responses in learning activities	Student

RESULTS AND DISCUSSION

Measurement of student creativity is carried out using observations on the achievement of the indicators listed in table 3.1. The indicators of student creativity observed were classified into five parts, namely: indicators (1) capturing ideas, indicators (2) originality of ideas, indicators (3) design hypotheses, indicators (4) design improvements, and indicators (5) optimistic. The results of observations on the five creativity indicators can be seen in table 2:

Table 2. *Observation result of 5 students' creativity indicator*

Score	Indicator 1		Indicator 2		Indicator 3		Indicator 4		Indicator 5	
	K	E	K	E	K	E	K	E	K	E
Mean	41.50	74.58	37.92	72.08	34.17	73.33	22.08	71.67	9.17	66.25
Highest	67	100	67	100	50	100	38	100	50	100
Lowest	7	50	17	50	13	50	0	50	0	50
SD	18.03	21.38	16.25	18.33	12.08	18.96	13.33	16.99	15.81	19.09
Varian	325.12	456.98	264.08	335.84	145.83	359.57	177.66	288.58	250.00	364.39

Description:
Indicator 1: Catching ideas
Indicator 2: Originality of ideas
Indicator 3: Design hypothesis
Indicator 4: Design improvements
Indicator 5: Optimistic

The results of the observations in table 4.3. shows the mean, highest and lowest value, standard deviation and variance. These data can be seen from the average value in the experimental class and control class. Overall, all indicators show that the experimental class is higher than the control class. In the experimental class, the highest score on indicator 1 (74.58) is the capture of ideas, while for the control class the highest value is the same as in the experimental class, namely indicator 1 (41.50) regarding capturing ideas and the lowest value is indicator 5 (66.25) in the experimental class and (9.17) in the control class that is optimistic.

In line with the results of Wicaksono's research (2020) which states that the supporting aspects in science learning that meet the demands of the industrial revolution 4.0 are using the STEM approach which is an example of implementing environmentally friendly technology that can increase student creativity. This is in line with the results of another study by Mardhiyatirahmah (2020) which stated that the positive impact of the STEM approach on the psychomotor aspect was marked by an increase in students' creative abilities.

The highest score achieved in the experimental class is in indicator 1 of 74.58 regarding the capture of ideas, the same as the experimental class in the control class, the highest value is found in indicator 1, which is 41.5. This shows that the five indicators are stages that students must go through to develop their creative potential. The curiosity indicator is the first step to achieve other indicators, and this is also owned by the control class. The lowest

p-ISSN 2614-8250, e-ISSN 2614-5677
https://journal.uniku.ac.id/index.php/IJLI

indicator in the experimental class is the optimism indicator in ideas, which is (66.25). This shows that the indicator of optimism is the most difficult stage for students to achieve, but it is not impossible for students to obtain. Optimism about ideas in students, the development process involves the potential for creativity in developing ideas, supported by the originality of the ideas. When the ideas are original, students need to be led to dare to hypothesize these ideas as outlined in the design. Growing the potential for hypothetical creativity needs to be supported by taking steps to pay attention to the advantages and disadvantages of the design to make design improvements. Seen in the group that has reached this stage, students are more optimistic about making the project they made. This research is in line with the opinion of Ledermen & Vagt-Traore in Suciati (2018) which states that process-oriented creativity refers to a mental process that involves a person's creative potential to develop new ideas, problem solving and self-actualization which must be carried out gradually.

Based on the results of data analysis, hypothesis testing was carried out using the chi square test (χ2) two samples. The calculation of the chi squared test uses a contingency table and can be seen from table 3 below:

Table 3. *Creativity hypothesis test results*

Group	Influenced	Not influenced	Number of samples
Experiment	28	7	35
Control	14	21	35
Total	42	28	70

The data in table 3 is useful for helping Yates correction. Furthermore, the data is processed using the chi square formula in Figure 3.2. The results obtained are equal to 10.05. With an error rate of 5% and dk = 1, then the price (χ2) table = 3.842. It turns out that the price (χ2) is greater than the price (χ2) table, thus there is an increase in student creativity due to the application of STEM 5E.

The ability to solve problems is measured by using a description test, which in each item tests three indicators, namely: indicator (1) recognizes the problem, indicator (2) identifies problems and indicators (3) provides solutions. The results of the problem-solving ability are shown in table 4 below:

Table 4. *Results of problem-solving ability*

Score	Indicator 1		Indicator 2		Indicator 3	
	K	E	K	E	K	E
Mean	53.14	94.28	42.00	74.57	27.24	74.47
Highest	80	100	70	100	40	100
Lowest	0	40	0	60	0	47
SD	23.23	12.43	18.91	13.14	12.03	14.42
Varian	524.41	154.62	347.43	172.61	140.63	207.81

Description:
Indicator 1: Recognize the problem
Indicator 2: Identify the problem
Indicator 3: Providing solutions

The results of observations in table 4 show the average, the highest and lowest values, standard deviation and variance. Overall, all indicators show that the experimental class is higher than the control class. The data in the experimental class in the control class shows the highest value, namely indicator 1 (94.28) in the experimental class and (53.14) in the control class, which is about the ability to recognize problems. And for the lowest value in the experimental class and control class is indicator 3 (74.47) in the experimental class and (27.24) in the control class, namely the ability to provide solutions to a problem.

The results of the data analysis of students' problem-solving abilities showed that the data were normally distributed and homogeneous. Thus, hypothesis testing is continued using parametric t-test statistics, using the formula in Figure 3.4. The results of the t count are 15, 35. The t price is then compared with the t table price. Because n1 and n2 are the same, then dk = n – 1 = 34. t table is at dk 30 and 40 at = 5%, the price of t table at dk 30 is 2.042 and the value of t 410 is 0.0084, then the results are added to t table at dk 30 so that it becomes 2.050. Based on these calculations, it turns out that t arithmetic is greater than t table (15.35 > 2.050). Thus Ho is rejected and H1 is accepted. So the conclusion is that there is a significant increase in problem-solving ability with the application of STEM 5E.

The results of student response data on the application of STEM 5E learning were taken using a questionnaire sheet containing 15 closed questions with three questions from the indicators of novelty in STEM 5E learning, three questions from the STEM 5E learning interest indicator, six questions from the ease of creativity indicator, and three questions from indicators of ease in solving problems. The attitude responses from respondents started with Strongly Agree (SS) to Strongly Disagree (STS). The following is a table of 5 student responses based on indicators:

Table 5. *Student response results*

No	Details	Score
1	Novelty of STEM Learning 5E	85.29
2	Interests in STEM 5E Learning	84.51
3	Ease in Creativity	85.30
4	Ease of troubleshooting	83.73
	Total	84.71

Based on table 5 about the results of student responses, it can be seen that the ease of creativity indicator is at the highest score of 85.30, this shows that STEM 5E learning for students helps grow their creativity. The lowest value of the student's response is the indicator of interest in STEM 5E learning, which is 84.51, this means that compared to other indicators, students consider interest not the main priority. Another thing that causes the low value of student interest in STEM 5E learning is not yet used to it. The results of the questionnaire that have been filled out by students are then added up and calculated based on the formula (Sugiyono, 2019):

$$\text{Percentage score} = \frac{2163}{2550} \times 100\% = 84{,}71\%$$

The percentage figure shows that the student's response is in very good criteria, thus students strongly agree that learning using STEM 5E is new, useful, and can increase their creativity and problem solving.

CONCLUSION

STEM 5E in learning is carried out through stages, namely: Science at the stages of binding, exploring and assessing. Technology at the stages of binding, working, and grading. Engineering at the stages of exploration, work and assessment. Mathematics at the stages of exploration, execution and assessment. With these stages, the experimental class students were higher in terms of creativity and problem solving.

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