

# THE EFFECTIVENESS OF STEM-BASED WORKSHEETS TO FOSTER STUDENTS' CREATIVE THINKING SKILLS

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## ABSTRACT

One of the learning approach that can be used to practice creative thinking skills is the STEM-based learning approach. This is effective if supported by teaching materials in the form of student worksheets. This study aims to determine the effectiveness of STEM-based worksheets to foster creative thinking skills of junior high school students. The design of this study used the pre experimental method in the form of the non equivalent pre test – post test design. Based on the results of the effectiveness test, it is known that the score of N-Gain at each learning activities has increased with the average score of the learning activities 1 in the amount of 0.48, learning activities 2 in the amount of 0.56, learning activities 3 in the amount of 0.58 and learning activities 4 in the amount of 0.59. The Students' creative thinking skills on each learning activities were increased in each indicator. The students' fluently thinking skills on the learning activities 1 with the score of 50 and the learning activities 2 with the score of 55 in the adequate criteria, the learning activities 3 with the score of 78 and the learning activities 4 with the score of 86 in the high criteria. The students' flexibility thinking skills on the learning activities 1 with the score of 66 and the learning activities 2 with the score of 75 in the high criteria, The learning activities 3 with the score of 80 and the learning activities 4 with the score of 85 in the very high criteria. The students' originally thinking skills on the learning activities 1 with the score of 54 and the learning activities 2 with the score of 56 in the adequate criteria, the learning activities 3 with the score of 84 and the learning activities 4 with the score of 85 in the very high criteria. The students' elaboration thinking skills on the learning activities 1 with the score of 34 in the low criteria, the learning activities 2 with the score of 63, the learning activities 3 with the score of 77 and the learning activities 4 with the score of 79 in the high criteria. Based on the study, it can be concluded that the STEM-based worksheet is effective to fostering junior students' creative thinking skills.

**Keywords:** STEM (Science, Technology, Engineering, and Mathematics), Worksheets, Creative Thinking

## 1. INTRODUCTION

The success of education in Indonesia has not yet achieved the expected results, so the education quality still needs to be improved. The education quality improvement is important to do, because education considered as the most valuable investment in the form of the human resources quality improvement for the development of a nation. Education teaches the students the right way of thinking, and provides accurate information to bring the right thinking skills to students (Bacanli et al, 2011). The various of thinking skills are a process and behavior of students who are integrated to learn and understand the learning materials content (Beers, 2011).

Thinking skills are the one component of life skills and a means for the accretion of communication skills and problems solving skills in the community life that really need the attention of teachers and education providers (Lovrich, 2004; Corebima, 2005). Through the thinking process, a person can develop the exploring and evaluating information skills, and assessing their decisions in daily life (Johnson, 2002). One of these thinking skills is creative thinking skills that make students be active in learning.

Creativity is a mental process in the form of ideas or new products, or combining both of them which will eventually be inherent in them (Gallagher, 2013). Whereas Clark (1994), a leading humanistic psychologist states that creativity is the experience of expressing and actualizing an individual's identity towards an integrated form in one's own relationship, with nature, and with others. Guilford in Humble et al (2018) states that there are four main components of creative thinking skills which include: fluently, flexibility, originality and elaboration. Fluently is the ability to generate many ideas; flexibility is the ability to produce more varied ideas; originality is the ability to produce new ideas or ideas that did not exist before; and elaboration is the ability to add or develop ideas so that produced the more detailed ideas.

In reality, the Indonesian students thinking skills are still relatively low, especially in science. The latest results of TIMSS (Trends in International Mathematics and Science Study) in 2012, the scientific literacy of Indonesian students have ranked 40th out of 42 participating countries with an average score of 406, still belovled the international average score that is 500 (IEA, 2012). The latest PISA (Program for International Student Assessment) in 2012, Indonesian students' scientific literacy have ranked 64th out of 65 participating countries with an average score of 382, where the average score is 501 (OECD, 2014). Based on the results of TIMSS and PISA studies, the students' scientific thinking skills are very low. Students do not have creative thinking skills in problem solving so learning be inactive and ineffective. To develop the active and effective learning depending on the teacher as learning manager, in reality the teacher still applies conventional learning, where the learning process in general only trains the convergent thinking process, so when get a problem, students will have difficulty solving the problem creatively (Munandar, 2009). Teachers are required to be able to provide opportunities so students try to build their knowledge independently. Therefore, the science teachers must be able to design and implement science learning by emphasizing the development of students thinking and collaborate skills positively. One of the learning approach that can be used to practice creative thinking skills is the Science, Technology, Engineering, and Mathematics (STEM) approach (Beers, 2011).

The study results by Roberts (2012), which reveal STEM-based learning can add to the learning experience through practical activities and apply general principles of the material being studied, so that creativity, curiosity and encouraging collaboration between students grow. STEM-based education forms human resources (HR) that are capable of reasoning and critical, logical, and systematical thinking, so that they will be able to encounter global challenges and be able to improve the country's economy (Nessar, 2017). Besides using of the right learning approach, the used of teaching materials present a very important role to produce effective learning activities, one of them by using student worksheets (Lee, 2014).

Ministry of National Education of Indonesia (2008) states that student worksheets are sheets that contain of tasks that must be done by students. Student worksheets are also material where students are given the steps should be learn (Yildirim et al, 2011). However, the most of worksheets currently used have not facilitated students to developing creative thinking skills. Student worksheets should be one teaching material that present an important role for ensuring the effectiveness of teaching and learning activities (Kaymakci, 2012).

The material to be presented in STEM-based worksheets is pressure in the liquid which includes hydrostatic pressure, Pascal's law, Archimedes's law and related vessels which applied in daily life. Besides material of pressure in the liquid can be taught by STEM approach, that is science in finding concepts, technology as an application in everyday life, engineering as a technique of designing technological tools that are applied in everyday life, while mathematic is used to learning the patterns and relationships between number, digit, and space. Mathematic is used in science, engineering and technology.

Based on previous study that has conducted on teachers and students, it can be known that 95% of teachers who use worksheets, where the worksheets used has not presented contextual material related to science, technology, engineering and mathematics that is able to improve students' creative thinking. Therefore, it is necessary to conduct research to determine the effectiveness of STEM-based worksheets that is able to improve the creative thinking skills of junior high school students.

## 2. METHODOLOGY

The design of study used was pre experimental in the form of non equivalent pre test – post test design. This design is used to observe the progress of students creative thinking after learning by using STEM-based worksheet. The data of study was obtained through a test instrument, in the form of questions. To observe the effectiveness of student learning outcomes, data was obtained by analyzing the score of students' pretest and posttest by using the Normalized gain (N-gain) formula. The gain index is calculated using the gain index formula as below:

$$N \text{ gain} = \frac{\text{post test score} - \text{pre test score}}{\text{IMS} - \text{pre-test score}}$$

Annotation:

IMS = Ideal Maximum Score

**Table-1** Gain score criteria

Gain Score	Criteria
$G < 0.3$	Low
$0.3 \leq g < 0.7$	Medium
$G \geq 0.7$	High

(Meltzer, 2002)

Students' creative thinking skills are obtained from the analysis results of student answers on worksheets and with indicators of creative thinking that have been developed. Assessment used to measure students creative thinking skills can use equations:

$$\text{Rating score} = \frac{\text{Number of the scores worked}}{\text{Number of the highest score}} \times 100\%$$

The calculation results are then interpreted using assessment classifications on Table-2.

**Table-2** Criteria for students' creative thinking skills

Percentage of Creative thinking	Criteria of Creative thinking
81% - 100%	Very High
61% - 80%	High
41% - 60%	Medium
21% - 40%	Low
0% - 20%	Very Low

(Arikunto, 2006)

### 3. RESULT AND DISCUSSION

This study measures the effectiveness of STEM-based worksheets to improve the creative thinking skills of junior high school students conducted in one class. This worksheets have been developed to foster students' creative thinking skills. The effectiveness test is carried out to determine the improve of student learning outcomes from the pre test and post test score in each learning, as well as the improvement of the students' creative thinking skills observed by the analysis of each student's answer in worksheets with the creative thinking indicators. The average score of the pre and post test for each learning can be seen in Table-3.

**Table-3** The average N-Gain test results

Learning 1			Learning 2			Learning 3			Learning 4		
Pre Tes	Post tes	N-Gain	Pre tes	Post tes	N-Gain	Pre tes	Post tes	N-Gain	Pre tes	Post tes	N-Gain
52,8	75,65	0,48	44,1	75,75	0,56	45,05	77,2	0,58	46,25	78,15	0,59
Category Adequate			Adequate			Adequate			Adequate		

The effectiveness test results are obtained based on the score of the pre and post test, the post test average score of learning 1 (75.65) > the pre test average score (52.8), the post test average score of learning 2 (75.75) > the pre test average score (44.1) , the post test average score of learning 3 (77.2) > the pre test average score (45.05) and the post test average score of learning 4 (78.15) > the pre test average score (46.25). Based on these results it can be concluded that there is an improvement in the average score of each learning, that means the average score of learning 4 is greater than the average score of learning 3, that means the average score of learning 3 is greater than the average score of learning 2, and the average score of learning 2 is greater than the average score of learning 1.

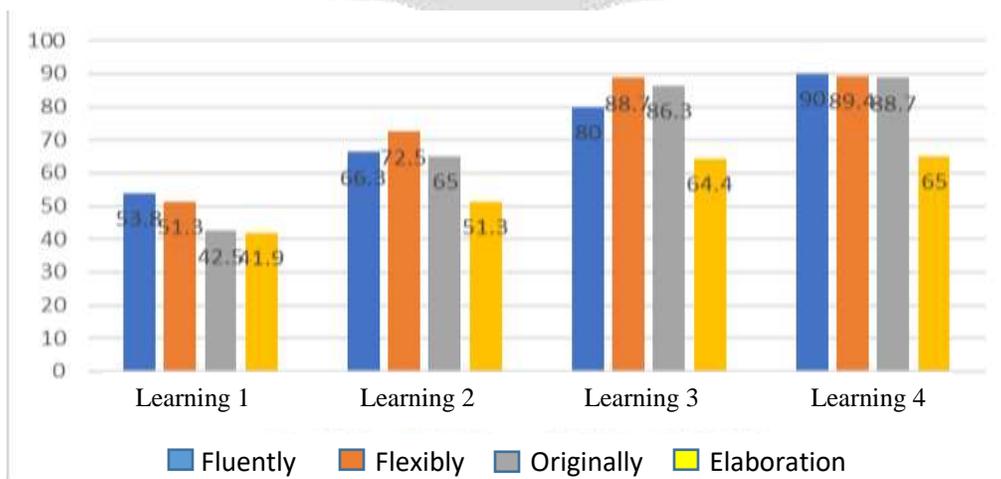
The improvement of students' creative thinking is also assessed. The assessment was conducted to determine the improvement of creative thinking by doing on the questions in the worksheets based on the creative thinking indicators on each learning. The improvement of creative thinking can be seen in Table-4.

**Table-4** The results of the students' creative thinking

Creative Thinking Indicators	Learning 1	Learning 2	Learning 3	Learning 4
Fluently	53.8	66.3	80	90
Flexibility	51.3	72.5	88.7	89.4
Originality	42.5	65	86.3	88.7
Elaboration	41.9	51.3	64.4	65

Based on Table 4, it is known that all indicators of creative thinking skills on an average increase on each learning after using STEM-based worksheets. It can be concluded that the each indicator of creative thinking skills in the high category.

Based on the assessment results have conducted, it is known that the students' initial creative thinking skills are still in low and sufficient categories, this indicates that students' creative thinking skills are still less trained. One of the contributing factors is that students are not accustomed to raising ideas to answer each question and to doing detailed steps and techniques for designing, because the worksheet used by the teacher has not explored the students' potential. After using the STEM-based worksheets, students are taught to obtaining data through observation by using detail and systematically steps and train students to design a teaching aid with techniques according to students' ideas. Students are able to answer each question with variation so that the creative thinking indicators possessed by students such as fluently, flexibly, originally and elaboration thinking have increased.



**Fig-1** Graph of the creative thinking indicators

The students fluently thinking skills for learning 1 and learning 2 in the adequate categories but after learning 3 in the high categories and learning 4 in the very high categories, this means that fluently thinking is fulfilled because it has increased, students have been able to describe events in daily life and connect with learned theories. The indicator of flexible thinking can be fulfilled by observing the students able to provide varied answers by looking at the questions given. Originally thinking skills have been fulfilled by observing the students answering questions from the results of their own thoughts associated with the new things in everyday life and elaboration thinking has also been fulfilled by observing the students who can answer questions in detail. The results of the effectiveness test are in line with the research conducted by Ritter et al. (2014) which states that the incubation stage which is the subconscious phase of the creative process contributes to creative thinking skills, while each individual has different abilities in reaching that stage. But overall the results obtained provide a pretty good picture of how STEM-based learning is able to improve students' creative thinking skills in a relatively short time and able to facilitate students in understanding a learning material (Rissanen, 2014).

Creative thinking skills can be fulfilled because one of the learning activities is presented in STEM-based worksheets. This is in line with study of Parwati et al. (2015), which states that in an environmental context that shows STEM learning can build creativity, scientific literacy and problem-solving skills that are needed to envisage the 21st century. Based on the explanation of Beladina et al. (2013), worksheets are able to support the process learning. Individual and group students can build their own knowledge with various learning resources and as a tool to build student knowledge. In line with the research of Pertiwi et al. (2017), STEM-based worksheets effectively trains students' creative thinking skills that can be observed from the improvement of students' creative thinking skills on each indicator. Therefore, it can be concluded that learning using STEM-based worksheets can improve the students' creative thinking skills.

#### 4. CONCLUSIONS

Based on the results and discussion, it can be concluded that STEM-based worksheets have been effectively used in the learning process, it can be observed from the results of the average post test 1 (75.65), post test 2 (75.75), post test 3 (77.20), and post test 4 (78.15) which have increased beside the pre test 1 (52.8), pre test 2 (44.1), pre test 3 (45.05) and pre test 4 (46.25). Whereas from the N-Gain score of each learning have increased, the learning 1 of 0.48 becomes 0.56 on the learning 2, the learning 3 of 0.58 and the learning 4 of 0.59 which are overall in the adequate category. In addition, the development of worksheets that effectively to foster the students' creative thinking skills can be observed through the improvement of each indicator of creative thinking such as fluently, flexibly, originally and elaboration thinking.

#### 5. ACKNOWLEDGEMENT

The author would like to thank Prof. Dr. Joko Waluyo, M.Si. and Prof. Dr. Sutarto, M.Pd. as an adviser.

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