The Effectiveness of STEM-Integrated Handouts to Improve Students' Creative Thinking Skills in Biotechnology Material

W Mentari[1*], Abdurrahman[2], dan T Jalmo[3]

[1]Magister Keguruan IPA, Universitas Lampung, Jl. Prof. Dr. Sumantri Brojonegoro, Bandar Lampung 35145, Indonesia
[2]Departemen Pendidikan Fisika, Universitas Lampung, Jl. Prof. Dr. Sumantri Brojonegoro, Bandar Lampung 35145, Indonesia
[3]Departemen Pendidikan Biologi, Universitas Lampung, Jl. Prof. Dr. Sumantri Brojonegoro, Bandar Lampung 35145, Indonesia

[*]wellymentari@gmail.com

Abstract. The development of science and technology was required students have all skills needed in the 21st century and be able to compete globally. One of which the skills is creative thnking skills. GCI (Global Creativity Index) and PISA study shows that the creative thinking skills of students in Indonesia were still low. One approach to learning that could be used to improve the skills of creative thinking is a STEM learning approach. It is effective if supported by teaching materials in the form of the handouts. The purpose of this study was to examine the effectiveness of STEM-integrated handouts to improve students' creative thinking skills in biotechnology material. The design of this study was a quasi experimental design in the form of nonequivalent pre-post control group design. The subject were 70 students Nine Graders Junior High School in Bandar Lampung, Indonesia with samples consisted of 35 students used STEM integrated handouts in experiment class and 35 students used text book in control class. Data were collected by test instrument for measuring creative thinking skills. The 10-item were applied as pretest and posttest and the data analysis used N-Gain. The results of the effectiveness test known that the value of N-gain in experiment class (0,64) was higher than control class (0,40). N-Gain of fluency (0,50) and originality (0,66) were medium category, while flexibility (0,74) and elaboration (0,74) were high category. It could be concluded that the STEM-integrated handouts has been effective to improve students' creative thinking skills in biotechnology material.

1. Introduction

The development of science and technology was required students to have all skills needed in the 21st century and be able to compete globally, one of which skills is a creative thinking skills. Creative thinking skill has a positive effect for students and their own environtment. The advantage of creative thinking is increased actualization and potential. Creatives people will given satisfaction their own surround because they given orginal and unique results [1].The results of the GCI and PISA study shows that students thinking skills were still low. Students weren't be a creative thinkers and problem solvers yet. Implementation of creative thinking and conceptual understanding of students has not been implemented, because teachers didn't have enough time to develop science learning tools which could improve creative thinking skills and understanding concepts in science learning [2]. In addition, most teachers still implemented conventional learning, where the learning process only trains convergent thinking processes, students felt difficult to solving problems creatively [3]. Observation junior high school in Lampung Province shows that the teachers not improved mastery of the material of students

and students couldn't solve problems. Based on the questionnaire of student needs, 54% of students stated that students were not required to think creatively. One of the learning approach to improve students creative thinking skill is STEM (Science, Technology, Engineering, Mathematics). STEM is an important issue in education [4] and was an alternative science learning that made generations which capable in 21st century [5]. STEM education is an integration of learning science, technology, techniques, and mathematics were suggested to have all skills needed in the 21st century [6]

STEM education train the students to increase their competencies to solve problems in several situations [7]. STEM could developed if it was connected with the environment. Students not only memorize concepts, but also understand the science concepts and their relationships in daily life. Therefore, the STEM approach was used in science learning. The STEM-integrated learning approach trained students to created designs which related to environment by utilizing technology [8]. The others survey results stated that the teacher didn't know about the STEM-integrated learning approach . The teachers who already know about STEM, never implemented the learning approach for learning on biotechnology material and 48% of students stated that in learning activities, students learnt science separately and not integrated. The teachers do not integrate scientific concepts with technology, engineering and mathematics.

Implementation of STEM approach learning was effective if it was supported by teaching materials in the form of the handouts. Handouts make the learning "portable and enduring" and lead to improved recall of information and improved test performance [9]. Handouts which could increase students learning interest, proved that using handout have higher average than students who do not use handouts [10]. Handouts could enhance students creative thinking skills from the learning process of students before and after using handouts [11]. The lack of handouts in learning process in schools an important problem and need development of handouts [12]. This was supported through a survey conducted on six teachers stating that these teachers never made STEM-integrated handouts.

2. Method

This study involved at 70 students nine graders Junior High School students in Bandar Lampung, Indonesia on February 2019. The population in this study were all class IX. With samples consist 35 students used STEM-integrated handouts in experiment class and 35 students used text book in control class. The instruments of research on creative thinking skills used include RPP, syllabus and test questions. The design of this study was a quasi experimental design in the form of nonequivalent pre-post control group design.

Data collected through pretest and posttest after being given treatment, the data obtained in the form of numbers or the form of quantitative data. The shape of the test in the form of essay questions reasoned ten items to analyze the categories of student achievement test used score pretest, posttest, and N-gain normalized. The results of the N-gain calculation were interpreted in Table 1.

Table 1. Interpretation of N-gain normalized

N-gain	Interpretation
N-gain > 0,7	High
0,3 < N-gain ≤ 0,7	Medium
N-gain ≤ 0,3	Low

The instrument you want to use have been tested before hand through validity test and test reliability. Then performed some tests: (1) Test for normality (2) Test of homogeneity (3) paired sample t-test (4) independent sample t-test (5) creative thinking skills test. The results of creative thinking skills fo each indicators were interpreted in Table 2.

Table 2. Interpretation of Creative Thinking Skills for Each Indicators

Percentage	**Criteria**
81 – 100	Very High
61 – 80	High
41 – 60	Enough
21 – 40	Low
0 – 20	Too Low

3. Results and Discussion

3.1 The effectiveness STEM-Integrated Handouts to Students' Creative Thinking Skills

Table 2. Average of Pretest, Posttest and N-Gain

Groups	Test	Average
Experiment Class	Pretest	47,51
	Posttest	81,57
	N-gain	0,64
Control Class	Pretest	54,37
	Posttest	75,63
	N-gain	0,40

According to the above data, it shows that the average of N-Gain in the experiment class (0,64) which used STEM-integrated handouts was higher than control class (0.40) which used text book. Based on the results, in experiment class it is known that 28.57% of students were high category and 71.43% of the students were medium category. In the control class it is known that 5.71% of students were high category and 65.71% of students were medium category and 28.57% of the students were low category. To verify that there are differences of average pretest to posttest of each groups (experiment class and control class) it is necessary to test paired sample t-test (Table 3)

Table 3. Paired Sample T-Test

Groups	Paired Sample T-Ttest	Wilcoxon Test
Experiment Class	Sig. (2-tailed) 0,000 < 0,05	-
Control Class	-	Sig. (2-tailed) 0,000 < 0,05

Based on the results of data analysis from the paired sample t test, the results shows Sig. (2-tailed) < 0,05 which means there was an increase between pretest to the posttest in the experiment class. Then because the normality test of the control class was not normally distributed, it was continued by Wilcoxon test and the results shows Sig. (2-tailed) < 0,05 which means there was an increase between pretest to the posttest in the control class.

To verify that there are effectivity STEM-integrated handouts, it is necessary to test of independent sample t-test (Table 4).

Table 4. Independent Sample T-Test

	Independent Sample T-Test	Mann Whitney Test
Pretest	Sig. (2-tailed) 0,115 > 0,05	-
Posttest	-	Sig. (2-tailed) 0,005 < 0,05
N-Gain	Sig. (2-tailed) 0,000 < 0,05	-

Based on the results of data analysis from independent sample t test, the pretest of the experiment class was smaller than the control class with Sig (2-tailed) 0,115 > 0,05. Then, because the normality test of the control class was not normally distributed, it was continued by Mann-Whitney test and the result shows Sig (2-tailed) 0,000 < 0,05, which means that the posttest of the experiment class was higher than the posttest of the control class. Thus, it concluded that using STEM-integrated handouts was more effective than using text book only.

3.2 The effectiveness STEM-Integrated Handouts to Each Indicator of Students' Creative Thinking Skills

Figure 1 shows the results data in measuring fluency, flexibility, originality and elaboration. In experiment class, the indicators of fluency and originality were medium category with N-Gain values of 0,50 and 0,66. For fluency, students used to think of more than one answer and have much ideas to solving problem. For originality, students have other ways of thinking than others. While, indicators of flexibility and elaboration were high category with N-Gain value of 0,74 and 0,79. For flexibility, students used to think of various ways to solving problem and have skills to classify things according to different divisions (categories). Then, for elaboration students could develop or enrich other people' ideas.

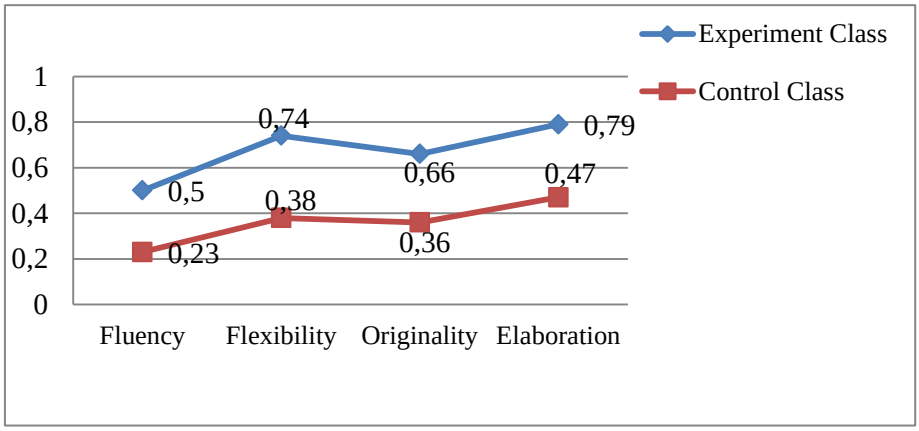

Figure 1. Increasing Fluency, Flexibility, Originality and Elaboration

Figure 1 also shows in control class, that the indicator of fluency were low category with N-Gain value of 0,23. Flexibility, originality and elaboration were medium category with N-gain value of 0,38, 0,36 and 0,47. Based on the results, it is known that the highest increasing indicators in the experiment class and the control class is an indicator of elaboration and each indicator of creative thinking in experiment class was higher than control class after using STEM-integrated handouts.

The decreasing of creative thinking in control class was caused ability to read, the habit of students getting knowledge only from teachers and students never do experiment in class [13]. Furthermore, in

experiment class, the teacher guides students to varying of experiments and made the project by STEM approach. The STEM approach makes students able to solve problems to be better, innovators, inventors, independent, logical thinkers, and technology literacy [14]. At the first meeting the teacher guides students to follow procedures to vary the variables in handouts. In line with the results showed that learning activities that are integrated with STEM could be an alternative solution to serve all skills needed in the 21st century [15].

4. Conclusion

Based on the results and discussions, it could be concluded that the handouts shows its role as an innovative teaching material in increasing students involvement to be active in the learning process. It has given the implication for the importance of creating variety of teaching materials for science learning which more meaningful and will provide provisions for the younger generation in facing the 21st century. STEM-integrated handouts could improve students' creative thinking skills in biotechnology materials and handouts was more effective in learning activities.

5. Acknowledgments

The researcher presents his sincere appreciation goes to both of my advisor Dr. Abdurrahman, M.Si., and Dr. Tri Jalmo, M.Si., for supervision, advice and guidance from very early stage of this research and helped me patiently finishing this research. I thank gratefully to all science teachers and students Nine Graders at SMPN 25 Bandar Lampung, Indonesia for allowing me to conduct the research there, and also my family of Master of Teacher Training and Science in Science Education in Lampung University who have been contribution and support during the study.

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