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

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## ABSTRACT

This study aims to know the effectiveness of STEM integrated handouts to improve students creative thinking skills in biotechnology material. The design used was nonequivalent pre-post control group design. This research was implemented in grade IX of SMPN 25 Bandar Lampung, Indonesia. The subject were 70 students divided into experiment class (N=35) and control class (N=35) with purposive sampling technique. The data collection was done by pretest and posttest for students creative thinking skills and students responses to the STEM integrated handouts. Based on the result, it were obtained that an average N-gain of experiment class was 0,64 greater than average N-gain of control class was 0,40. Both of class in medium category. Average N-gain of fluency was 0,50 and originality was 0,66 with medium category, then average N-gain of flexibility was 0,74 and elaboration was 0,79 with high category. The student responses showed almost all of the students agreed to the implementation of STEM integrated handouts improved interesting and motivating in biotechnology material.

**Keywords:** STEM, creative thinking skills, biotechnology

## INTRODUCTION

The 21st century required students to have various skills and to be able to compete globally. One of thinking skills is creative thinking. Creative people will give satisfaction to the surrounding environment because the persons actions are carried out in a fast time, giving the right and many results, and the resulting work is original and unique [1]. Creative thinking is also needed to solve problems in the community. But in reality, Indonesian students thinking skills were still low, especially in science. It could be seen from the research of GCI (Global Creativity Index) 2015 which shows that Indonesia is ranked 115th of 139 countries [2]. Besides GCI, the results of the PISA study found shows that students thinking skills were still low. Students do not yet have the skills to become creative thinkers and problem solvers. This is supported by research [3] that the implementation of students creative thinking and conceptual understanding has not been implemented maximally yet because the teachers limited time to develop science learning tools to improve creative thinking skills and understanding concepts in science learning. In addition, most teachers still apply conventional learning, where the learning process only trains convergent thinking generally, so that when faced with a problem, students have difficulty solving problems creatively [4]. Based on the fact that creative thinking skills are not fully implemented, one of the learning approach to improve students creative thinking skills is STEM (Science, Technology, Engineering, and Mathematics) learning approach.

STEM is an important issue in education today [5] and is an alternative learning science that could build generations to face the challenging of 21st century [6] because STEM learning is an integration of learning science, technology, engineering, and mathematics that is suggested to help 21st century skill success [7]. The STEM approach aims to make better their understand when they do interaction in the community, they will be able to develop their competencies to various situations and problems in daily life [8]. STEM can develop when it is associated with the environment, so that a learning is realized that presents the real world experienced by students in daily life [9]. Therefore, the STEM approach is

suitable for use in science learning because it could improve students to apply their knowledge to create designs as a form of solving problems related to the environment by utilizing technology. It was proved by research [10] that learning by integrating STEM knowledge is able to influence the level of creativity of students.

Based on the statement, it was needed STEM based learning through teaching materials and according to the students thinking skills. One teaching material that could be applied using the STEM-based learning approach is handouts. Handouts make learning "portable and enduring" (easy to carry everywhere and eternally) and recall information that has been obtained by students and develop tests for students [11] Besides that, handouts could increase students interested in learning, where students used handouts have a higher average value than students who do not use handout [12]. In addition, to increasing interest in learning, handouts could also improve students creative thinking skills. This is also supported by research [13] which states that handouts could improve students creative thinking skills that could be seen from the learning process of students before and after the use of handouts.

## MATERIAL AND METHODS

### Methods

This research method is quantitative with nonequivalent pre-post control group design. This research was conducted at SMPN 25 Bandar Lampung , Indonesia on February 2019, with population of 70 class IX students consisting of 35 experimental class students and 35 control class students by purposive sampling technique.

### Instrument

The conception test instrument that was developed to find out the conception of preservice elementary school teacher students was 7 items. Test items used the four-tier test format. The conception test validation was judged by two physics education experts and one theoretical physicist. The results of the validation of the conception test items indicated that the validator generally stated that the items to be used are valid both in content and construction. Validators provided some notes that are suggested to be revised, especially those that are considered inappropriate, that is, related to accepted scientific theory, image clarity, sentence editorial, and written order. The research instrument was in the form of several multiple-choice items on the concept of force and motion that require explanations about the selected answers. To find out the participants' *conceptual change*, they wrote their responses towards several written statements (Yes/No/Not always) and with confidence levels (Sure/Not really sure/Not sure). The participants answered the questions individually and do not include their names to ensure their anonymity.

### Procedures

In the preliminary study, Direct Instruction and discussion methods were used. After knowing the conceptual change profile that occurred, then the remedial teaching was conducted. It was adopted by the *reflective conceptual change* model of Chinn and Brewer (1993) and Aydenis and Brown (2010, 2017) and the cognitive conflict process model of Lee *et al.* (2003) and Hadjiachilleos *et al.* (2013), namely The Multimedia Visual Reflective Conceptual Change Model (RCCM). This learning model covering three stages, namely pre-learning, learning process and post- learning. The pre-learning goal is to uncover the initial predictions/ conceptions of the preservice elementary school teachers related to the concept of Style and Motion through revealing puzzle questions so that interrogative sentences are used. The stages of the process include practices and reiterate. The expected goals in this stage are:

(1) conducting evidence to solve phenomena or experimental results; (2) comparing the "genuineness" of the problem with their initial conception; (3) developing and evaluating conceptions scientifically; and (4) building stronger conceptions using different discrepant events. In order to support this goal, it is necessary to design visual multimedia such as video phenomena, video animation, and equipment that supports and can explain the discrepant event phenomenon. Whereas in the third stage in the form of evaluation, it aims to map learning progression and conceptual change for preservice elementary school teachers' conceptions about Force and Motion.

## Data Analysis

The type of data is quantitative data obtained from the results of the pretest and posttest. The pretest and posttest data were analyzed to know increasing after using the STEM integrated handouts through 10 items. The amount of increase is calculated by the formula:

$$N - gain = \frac{posttest - pretest}{score\ max - pretest} \times 100$$

The results of the N-gain calculation are interpreted using classification (**Table 1**).

**Table 1.** N-gain Classification

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

The results of N-gain calculation of students creative thinking skills in experiment class and control class could be interpreted using classification (**Table 2**).

**Table 2.** Classification Score of Creative Thinking

Percentage (%)	Classification
81 - 100	Very High
61 - 80	High
41 - 60	Medium
21 - 40	Low
0 - 20	Very Low

## RESULTS AND DISCUSSION

### Students Creative Thinking Skills

The effectiveness of STEM integrated handouts on students creative thinking skills have shown at **Table 3**.

**Table 3.** Average of N-gain Creative Thinking Skills

Group	Average Score	Classification
N-gain Experiment Class	0.64	Medium
Control Class	0.40	Medium

Based on the data in Table 3, there are differences between N-gain of experiment class and control class where the N-gain of experiment class using the STEM integrated handouts was greater than the N-gain of control class that use text book.

**Table 4.** Percentage of students Creative Thinking Skills

Groups	Percentage (%)	Classification
Experiment Class	28.57	High
	71.43	Medium
Control Class	5.71	High
	65.71	Medium
	28.57	Low

Based on the data in Table 4, the students creative thinking skills of the experiment class was greater than the control class, because no students have the "low" category in the experiment class and no students have the "high" category in the control class. This shows that the use of STEM integrated handouts is more effective than using text book.

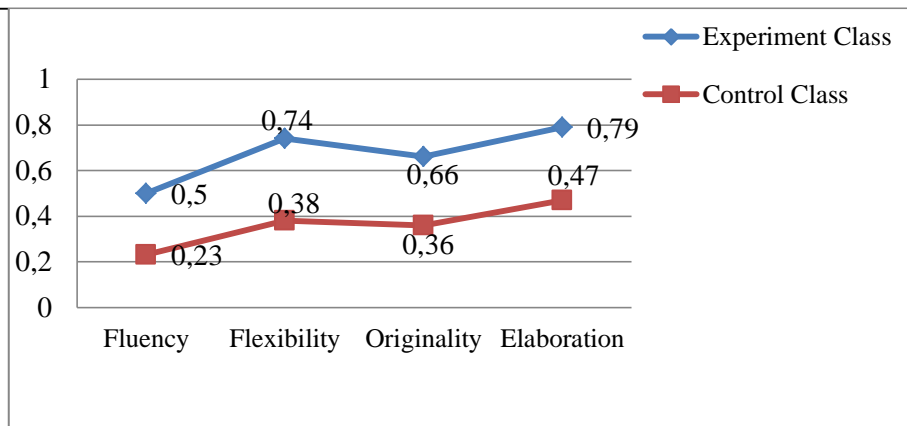


Figure 1. Increasing Creative Thinking Skills for Each Indicators

Based on the results of the tests conducted on each indicator of creative thinking, all indicators of creative thinking skills in the experiment class have increased after using the STEM integrated handouts in learning. Indicators of fluency and originality have "medium" category. Meanwhile, indicators of flexibility and thinking of elaboration have "high" category. In the control class, for fluency have "low" category. Meanwhile, indicators of flexibility, originality, and elaboration have "medium" category. Based on the results of N-gain calculation, the achievement of indicators of creative thinking, it is known that the highest indicator of in the experiment class is elaboration. It can be concluded that the creative thinking skills for each indicators of experiment class increases after using the STEM integrated handouts.

The amount of N-gain in the experiment class (Table 3) was caused by handouts as an instructional materials for handouts which were used to supplement teaching materials that have deficiencies in achieving the objectives in the learning process that could be adjusted to the characteristics of students, types of subject matter, situations and could motivate and improve students learning in biology and it developed based on the conditions of students in accordance with the purpose of learning that apply the material in the learning process in daily life clearly [14]. This is supported by Rahmayani [15] which states that handouts are able to complement the weaknesses of textbooks in the learning process and more effective used in learning on biotechnology material.

Increasing creative thinking skills for each indicator (Figure 1) because the teacher guides students in explaining the activities of varying experiments and making project assignments by applying the STEM approach. At the first meeting the teacher provides guidance to students to follow the procedure of varying the variables contained in the handout, so that students are able to complete all activities in the handout. Learning activities that are integrated with STEM could be an alternative in improving all skills needed in the 21st century [16]. This is supported by the statement that STEM is a meta-discipline at the school where teachers of science, technology, engineering and mathematics teach education as a dynamic entity. STEM is an approach that explores learning between two or more STEM subject areas and / or between STEM and other school subjects, for example technology cannot be separated from social learning, arts and humanities [17]

Table 5. Students Responses

Aspects	Presentase (%)	Kriteria
Attractiveness	82	Very Interesting
Usefullness	83	Very Usefull
Legibility	80	Very Legible

Based on the students responses (Table 5) almost all students are interested using STEM integrated handouts because students are trained to conduct experiment activities and observations by the groups. The benefits obtained are students understand steps in working on a project in the form of biotech products and more creative because it provides an opportunity to vary the tools and materials in making biotech products. It was caused the learning environment supports student activities to complete all activities in the handouts, so that to create a learning climate that supports students to solve problems, appropriate strategies are needed in order to develop students thinking skills [16].

## 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.

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