THE IMPLEMENTATION OF STEM BASED STUDENT WORKSHEETS TO IMPROVE CREATIVE THINKING SKILLS AND LEARNING RESULTS

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Abstract

The ultimate goal of the expected science learning process is students have cognitive abilities, skills, and scientific attitudes. Creative thinking skills are one of the important aspects that need to be provided to students. Equipping creative thinking skills inspired by the science learning process is still rarely done by science teachers. To be able to develop students' creative thinking skills, teachers need to use appropriate learning strategies and approaches. This study was conducted to examine the effectiveness of STEM-based student worksheets to improve creative thinking skills and student learning outcomes. This research was conducted in one of the Senior High Schools, in Banda Aceh City, Aceh, Indonesia. The research method used is the experimental method, pretest-posttest control-group design. The research subjects were 67 students, divided into two experimental classes 33 students, and 34 control class students. This research was conducted for 30 days (September-October 2018). The parameters measured in this study are creative thinking skills, learning outcomes, and student creativity. Data on creative thinking skills and learning outcomes are analyzed by comparing the initial abilities (pre-test results) with the final ability (N-gain) and tested for significance through two different test averages using independent sample t-test. The results showed that the average initial ability of students towards creative thinking skills and learning result (cognitive) was not significant between the experimental class and the control class. While the final ability shows significantly different results. The creativity level of the experimental class (elaboration 1.48, originality 1.67, and fluency 1.39), was higher than the control class (elaboration 1.21, originality 1.35, and fluency 1.12). Conclusion of the research results that the application of STEM-based student worksheets is very effective in improving creative thinking skills, learning outcomes, and student creativity.

Keywords: STEM, Creative Thinking Skills, Learning Outcomes.

1. INTRODUCTION

The main responsibility in education scope is to teach students the right way of thinking, one of those is creative thinking skills (Bacanli et al. 2011). Creative thinking skills is the ability of students to answer the problems based on existing information with various kinds of alternative answers, the answers given show originality, flexibility, fluency and elaboration (Pangesti et al,, 2017). Creative thinking skills is one of the thinking skills that was developed in the 21st century. However, to develop these thinking skills the teachers must have the right learning strategies to improve students' creative thinking skills. Most teachers in schools still apply conventional learning method, where the learning process in general only trains the process of convergent thinking, so that facing a problem, students will find it difficult to solve the problem creatively (Munandar, 2013).

The results of the study conducted relate to creative thinking skills in November 2017 at SMA Negeri 4 Banda Aceh, the researcher found some problems. The rare use of laboratories related to physics learning, due to the limitations of the tools that exist in the laboratory. To overcome this, the teacher only gave project assignments to students divided into groups. As well as the lack of companion teaching materials used by the teacher, so that it has not yet helped students in solving problems and improving their skills. Practical activities that carried out by students all this time were only reading and observing according to work procedures and compile reports of the observations.

Instant practice activities that were implemented in schools so far could not help students to practice their creative thinking skills. To overcome these problems, the right learning strategy is needed, because students' creativity depends on the teachers to find out how the creativity tha was developed (Bayindir & Inan, 2008). One of the learning approaches that can be used by teachers is to train students' creative thinking skills, namely Science, Technologhy, Engineering and Mathematics (STEM). STEM is an important issue in education today (Kuenzi, 2012). STEM learning does not only mean strengthening the STEM field of practical education separately, but to develop educational approach that integrates science, technology, engineering and mathematics by focusing on education and daily life (Akaygun & Tutak, 2016).

STEM is a learning approach that can develop creative thinking skills. This has been proven by Pertiwi at al. (2017) developing STEM-based student worksheets was effectively trained students' creative thinking skills. Aldila et al. (2017) showed the effectiveness of STEM worksheets were able to train students' creative skills. A similar study was also conducted by Susanti et al. (2018) that the application of STEM-based learning media could improve learning outcomes. This is also in line with Nurkhalisa & Mastura (2017) research that the STEM approach could improve student learning outcomes and character. Adlim et al (2015) obtained results that 90% of students scored above the minimum completeness criteria (KKM) by applying the STEM module. Syukri et al. (2013) found out the achievement and interest in learning of students in science learning increased by using the entrepreneurship-based STEM approach.

Some previous studies on learning with the STEM approach showed positive influence on creative thinking skills and student learning outcomes. Other researches was obtained by Widya et al. (2017), it showed that student books based on STEM problem based learning gave a potential effect on learning. Pangesti et al. (2017) stated that STEM-based teaching materials could improve mastery of students' concepts which was marked by an increase in the value of the pretest to posttest in the learning process.

The implementation of STEM indirectly requires teachers and students to think creatively. In addition to using an integrative approach teachers are required to be creative in developing teaching materials, because teaching materials used by teachers influence student learning outcomes significantly. Therefore teaching materials are needed to support the learning process, which is student worksheets. Many studies that discussed STEM learning on the learning process gotten positive results, but STEM-based teaching materials to measure both variables between creative thinking skills and learning outcomes are still limited. Therefore, this study was conducted to test the effectiveness of learning by applying STEM-based student worksheets towards creative thinking skills and student learning outcomes in Pascal's legal material.

2. RESEARCH METHOD

The method used in this study was the experimental method with the pretest-posttest control group design. The research design is shown in Table-1.

Table-1: Pretest-Posttest Control Group Design

Sample	Class	Initial test	Treatment	Final Test
Random	Experiment	O1	P_1	O2
Random	Control	O3	P_2	O4

INFORMATION:

O1 = Initial test (pretest) before treatment was given in the experimental class

O2 = Final test (posttest) after treatment was given in the experimental class

O3 = Initial test (pretest) before treatment was given in the control class

O4 = The final test (posttest) after treatment was given in the control class

P1 = Treatment of the experimental class

P2 = Treatment of the control class

The study was conducted by involving the entire population, which were the class XI students of SMA 4 Banda Aceh as many as 170 students spreaded in five classes. The sample selection was determined through a pretest score performed on five classes. From the five classes, two classes were taken whose the average score of the pretest had the same initial ability or not significantly different. Class XI IA 5 was determined to be an experimental class with 33 students and XI IA 2 set as control class with 34 students. This research was conducted in the odd semester of the 2018/2019 learning year on September 5 to October 5, 2018 with each classes arranged for 3 meetings.

3. DATA AND ANALYSIS

The indicators measured in this study were the students' initial abilities and final abilities towards creative thinking skills and learning outcomes. The questions used in this study were previously tested to determine the validity, reliability, level of difficulty and distinguishing items. After getting the questions that fit the criteria well, then the questions were used as a tool to measure students' initial abilities and final abilities towards creative thinking skills and learning outcomes. To analyze the creativity of students obtained from the modified creativity sheet in the form of scoring using an instrument developed by Torrance (1966), namely torrance test of creative thinking. Indicators of creativity observed were elaboration, originality, and fluency.

4. FINDINGS AND DISCUSSION

The measurement results and analysis of the initial abilities and final abilities of students towards the creative thinking skills presented in (Figure-1) showed the average scores of the pretest, posttest and N-gain of the experimental class and the control class. The average score of the experimental class pretest was 43.83 and the control class was 43.19. The average score of the experimental class posttest was 87.33 control class 71.51. The average score of the experimental class N-Gain was 81.05 and the control class was 51.86.

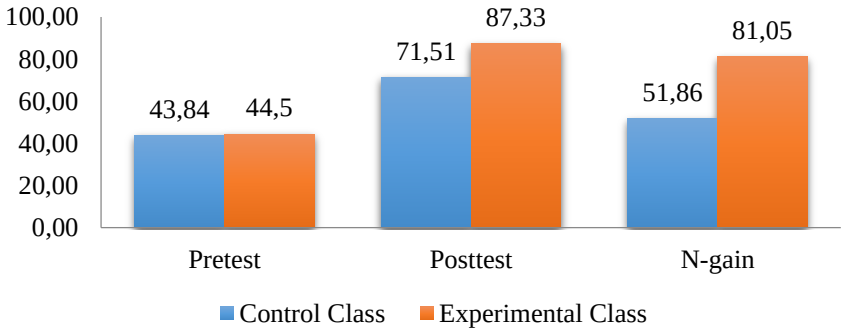

Figure 1. Average Score of Pretest, Posttest and N-Gain Creative Thinking Skills of Control Class and Experimental Class

The differ test results of average pretest scores on creative thinking skills in (Table 2) showed that the initial abilities of the experimental class students and the control class were not significantly different. This means that the initial ability of the experimental class students and the control class is the same. Furthermore, the increasing in the final ability of students based on N-Gain data analyzed using two differ test of averages scores showed significant difference.

Table 2. Differences in the average score of pretest and N-Gain creative thinking skills

Creative Thinking Skills	Class	Average Score	Normality*	Homogeneity**	Significancy***
Pretest	Experiment	44,50	$X^2_{hit} < X^2_{tab}$ (3,65) < (5,99) (normal)	$F_{hit} < F_{tab}$ (1,77) < (1,84) (homogeneous)	$t_{hit} \geq t_{tab}$ (4,60) ≥ (1,66) (significantly different)
	Control	43,84	$X^2_{hit} < X^2_{tab}$ (6,64) < (7,81) (normal)		
N-Gain	Experiment	81,05	$X^2_{hit} < X^2_{tab}$ (3,65) < (5,99) (normal)	$F_{hit} < F_{tab}$ (1,77) < (1,84) (homogeneous)	$t_{hit} \geq t_{tab}$ (4,60) ≥ (1,66) (significantly different)
	Control	51,86	$X^2_{hit} < X^2_{tab}$ (6,64) < (7,81) (normal)		

Information :

*) = Chi square test (normal, value $x^2_{hit} < x^2_{tab,}$ α=0,05)

**) = F Test (homogeneous, value $F_{hit} < F_{tab}$, α=0,05)

***) = T Test (significant, $t_{hit} < t_{tab,}$ α=0,05)

The increasing the N-Gain average score on students' creative thinking skills after being given treatment showed significant difference. This shows that creative thinking skills between the experimental class and the control class differ significantly. Thus the contribution of the STEM-based student worksheets application could improve students' creative thinking skills. This is proven by the increasing in the average score of the experimental class N-Gain which was treated with the application of STEM-based student worksheets was higher than the average score of the control class that only applied Conventional student worksheets. The results of the different N-Gain scores showed significant differences (Table 2). Thus it can be believed that the application of learning by implementing of STEM-based student worksheets is very effective for improving students' creative thinking skills.

The results of the analysis of the initial ability and final ability of students towards learning outcomes between the experimental class and the control class presented in (Figure-2) showed the average scores of the pretest, posttest and N-gain experimental class and control class.

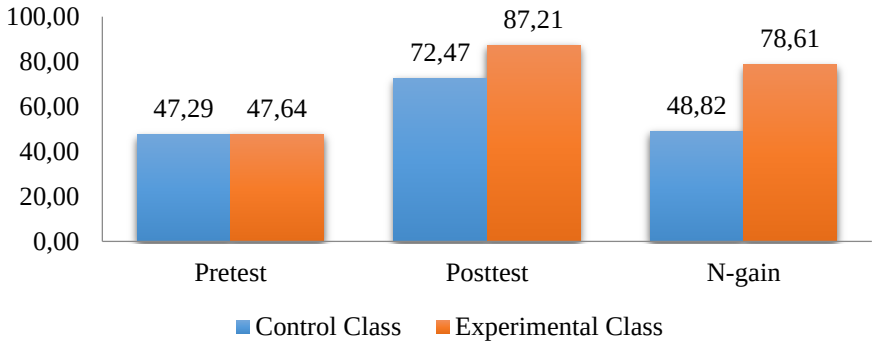

Figure 2. The Average Score of The Pretest, Posttest and N-Gain Learning Outcomes of The Control Class and The Experimental Class

The differ test results of average pretest scores on learning outcomes (Table 3) showed that the initial ability of the experimental class students and the control class was not significantly different. This means that the experimental class and control class students have the same initial abilities. Furthermore, the increasing in the final ability of students based on N-Gain data analyzed using two differ tests of average scores showed significant difference. To prove the results of the analysis of the final ability of the experimental class and control class students will be presented in Table 3.

Table 3 Differences in the average pretest and N-Gain learning outcomes

Learning Outcomes	Class	Average Score	Normality*	Homogeneity**	Significancy***
Pretest	Experiment	47,67	$X^2_{hit} < X^2_{tab}$ (1,48) < (7,81) (normal)	$F_{hit} < F_{tab}$ (1,12) < (1,84) (Homogeneous)	$t_{hit} < t_{tab}$ (0,11) < (1,66) (not significantly different)
	Control	47,29	$X^2_{hit} < X^2_{tab}$ (3,17) < (7,81) (normal)		
N-Gain	Experiment	78,61	$X^2_{hit} < X^2_{tab}$ (2,25) < (5,99) (normal)	$F_{hit} < F_{tab}$ (1,37) < (1,84) (homogeneous)	$t_{hit} \geq t_{tab}$ (5,22) ≥ (1,66) (significantly different)
	Control	48,82	$X^2_{hit} < X^2_{tab}$ (4,78) < (5,99) (normal)		

Keterangan :

*) = Chi Square Test (normal, value $x^2_{hit} < x^2_{tab,}$ α=0,05)

**) = F Test (homogen, value $F_{hit} < F_{tab}$, α=0,05)

***) = T Test (signifikan, $t_{hit} < t_{tab,}$ α=0,05)

The increasing of the average N-Gain scores on student learning outcomes after being applied STEM-based student worksheets showed significant difference. It showed the increasing in learning outcomes of experimental class and control class students was significantly different. Thus the application of STEM-based student worksheets gave positive effect on the learning process which showed by the increasing in the N-Gain average score of the experimental class applied with STEM-based student worksheets was higher than the average score of the control class that applied with Conventional student worksheets. The results of the different N-Gain scores showed significant difference (Table 5). Thus it can be believed that the application of learning by implementing STEM-based student worksheets is very effective for improving students' creative thinking skills.

The data obtained from research clearly shows that the application of STEM-based student worksheets is truly effective in improving creative thinking skills and student learning outcomes. This is evidenced by the increasin in the average score of the experimental class N-Gain which was treated with the application of STEM-based student worksheets was higher than the average score of the control class that was only applied of Conventional student worksheets. This is supported by Susanti et al. (2018) which proved that the application of STEM-based learning media could improve student learning outcomes. Nurkhalisa & Mastura (2017) stated that the STEM approach could improve student learning outcomes and character. STEM-based learning could improve students 'creative thinking skills supported by Pertiwi at al. (2017) research which proved that STEM-based student worksheets could improve students' creative thinking skills. Aldila et al. (2017) found out that the effectiveness of STEM-based student worksheets has been able to train students' creative thinking skills. Projects given to students were able to improve cognitive systems because by implementing project-based learning, it provides opportunities for students to create multifunctional objects that in accordance with Pascal's legal concepts. So that students could get more information by reading various references so that they become more active, increasing self-confidence, learning motivation, communicative and creative.

The analysis results of student creativity presented in (Figure-3) showed that the average score of creativity for the experimental class on the elaboration indicator was 1.48, originality 1.67 and fluency 1.39 while for the control class on the indicator elaboration was 1.21, originality 1.35 and fluency 1.12. Based on these scores it can be said that the value of creativity of experimental class students was higher than the control class for each indicators. Creativity indicators for indicator of elaboration, originality and fluency had a maximum score of 3.

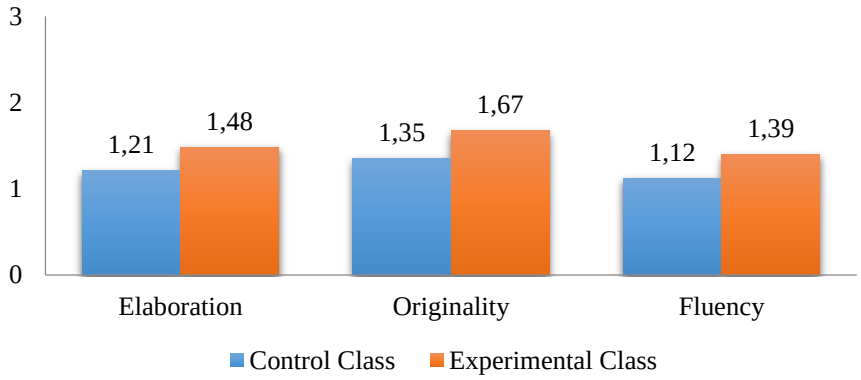

Figure 3. The Average Score Of Creativity In The Control Class and The Experimental Class

Overall indicators of creativity (elaboration, originality, fluency) showed better results in the experimental class that applied of STEM-based student worksheets compared to the control class that applied Conventional student worksheets in the learning process. These results have provided emperical evidence that the learning process by implementing of STEM-based student worksheets is able to improve various student abilities including creativity (Cunningham & Hester, 2015; Ersoy & Baser, 2014; Neber & Neuhaus, 2013).

5. CONCLUSION

The implementation of STEM-based student worksheets is truly effective in improving creative thinking skills and student learning outcomes. This is evidenced by the increasing of the average N-Gain scores in the creative thinking skills category was 81.05 and the learning outcome category was 78.61.

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