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The Comparison of Student Creative Thinking Skill using CBL Implemented in STEM Education and Combined with PSL Worksheet in Indonesian School

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ABSTRACT The main goal of this study is to present the effectiveness improvement of student's creative thinking skills using CBL implemented in STEM education and CBL combined with worksheet PSL. The STEM education perspective used in this study is a separate science discipline (Physics) that incorporates other disciplines. The research method used in this study is a quantitative method with a quasi-experimental research design. The research includes a pre-test-post test control group design. The subjects of the research consist of forty-five students in 10th grade of one of the vocational schools. The instrument used in this study is an essay test consisting of four questions with indicators of fluency, flexibility, and originality. The enhancement of students' creative thinking skills is known by analyzing normalized gain (<g>) on the experimental group and control group. A non-parametric test and Cohen's Kappa test were used to examine differences improvement of student's creative thinking skills with the IBM Statistics SPSS 20.00 program at .05 significant levels. As a result of the research, it was found that CBL implemented in STEM education has a higher improvement for students of creative thinking skills than CBL combined with worksheet PSL. CBL implemented in STEM education also has a major impact on improvement of students' creative thinking skills.

Keywords STEM education, Challenge based learning, Creative thinking skill

1. INTRODUCTION

Torrance in Treffinger, Young, Selby, & Shepardson (2002) explained that indicator of creative thinking skills is fluency, flexibility, and originality. Zhou in Eldy and Sulaiman (2013) mentioned creative thinking skills are abilities or talents that exist in students who must continue to be trained so that they can hone these skills for the better. The results of interviews of teachers and student's on the implementation of physics learning in one of the schools in Indonesia show that the transfer of knowledge in an appropriate manner in the learning process is still not done. The learning process has not directed student's towards the reconstruction of knowledge to be able to analyze phenomena, solve problems and think creatively. The learning process that takes place uses lecture methods, demonstrations, practicum verification and mathematical problem-solving. Students' orientation in learning physics material is only to be able to solve physics content problems quickly and easily. Evaluation questions developed have also not directed students to be able to think and process their knowledge to be able to solve problems creatively with a physics perspective. The results of the interviews also showed that students felt that the learning process currently being carried out still prioritized the study of theory and had not yet trained students' skill processing in an in-depth assessment of physical content.

Study of the implementation of CBL in six schools throughout the United States, showed that, 90% of teachers stated that there were significant changes in 12 primary skills in learning (leadership, creativity, media literacy, problem-solving, critical thinking, flexibility, and adaptability) after the application of the CBL model, 70% of teachers stated that the application of CBL could improve the ability of 21st century skills, more than 90% of teachers stated that they could streamline learning time, more than 75% of teachers stated that they were able to improve the ability to grasp material, and student involvement in learning (Johnson & Adams, 2011), the

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application of CBL in learning can improve students' creative thinking skills (Yang et al., 2018; Nufus, Duskri, & Bahrun, 2018; Ardiansyah et al., 2018).

Eldy and Sulaiman (2013) revealed that the lack of creative thinking skills occurs because creative thinking education has not been grown and handled by the correct procedures. Therefore appropriate learning innovations are needed such as through the implementation of approaches or the use of learning support.

Research that has been done shows that the application of STEM in learning can improve creative thinking skills (Henriksen, 2014; Ugras, 2018; Yasin, Prima, & Sholihin, 2018; Apriyani, Ramalis, & Suwarma, 2019; Hanif, Wijaya, & Winarno, 2019), preparing students to develop the skills needed in 21st century education (Sanders, 2009), has a significant effect on increasing student achievement (Becker & Park, 2011), effectively applied in the learning process and achieving learning objectives (Borchers, El-Sayed, & Hoff, 2012), scientific investigations and the discovery of biological content (Osman, Hiong, & Vebrianto, 2013), are able to instill creative problem solving techniques in students and development future innovators (Roberts, 2012), increase student innovation and learning outcomes (Ceylan & Ozdileka, 2014), enhance metacognitive skills and student interest in science lessons (Anwari et. al., 2015), create concrete and meaningful learning (Le et al., 2015) as well as learning outcomes and scientific process skills (Saraç, 2018).

Supporting learning assessed according to other CBL frameworks, is the use of worksheets. Williams (1941) mentions that a worksheet is one of the learning tools that can facilitate active student learning. Worksheets are task sheets in the form of questions as a guide for students that can be used to support learning in an informal learning environment (Nyamupangedengu & Lilliot, 2012).

Research related to the use of worksheets in learning has been widely carried out and proven to be able to improve creative thinking skills (Luthfiana, Ambarita, & Suwarjo, 2018; Nurisalfah, Fadiawati, & Jalmo, 2018), hypothetical thinking abilities, correlations and combinational students (Bakırcı, Bilgin, & Simsek, 2011), improve reading skills, scientific understanding and analysis (Ayva, 2012), learning success (Ulaş, Sevim, & Tan, 2012), creating meaningful learning (Celikler & Aksan, 2012), making it easier for students to understand the content of science lessons (Sharma, 2014), students' scientific achievement (Lee, 2014).

The purpose of this study is to examine the effectiveness of improvement of students 'creative thinking skills using CBL implemented in STEM education. This study is expected to be able to add previous research related to methods or ways that can be done to improve students' creative thinking skills in Physics learning.

Table 1 Research design

Class	Pre test	Treatment	Post test
Experimental	O	X_1	O
Control	O	X_2	O

2. METHOD

This research used the quasi-experimental method. The research design used a pre-test-post test control group design as tabulated in Table 1. The population in this study was all students of 10th grade in one of the vocational schools in Indonesia. Forty-five students' were chosen as participants divided into experiment class who taught CBL implemented in STEM education and in control class who taught CBL combined with worksheet PSL. The research was conducted four times the teaching and learning process in class.

The instrument of data collection for creative thinking skills was an essay test format. The test included four questions developed based on the indicators of creative thinking skill by Torrance. Students were given two tests of creative thinking skills for pretest and posttest with the same instrument. The instrument of creative thinking skill test was validated by three expert judgments and tested. The results of the expert judgment explained that the instrument can be used to measure creative thinking skills. The result was tested and analyzed using correlation product-moment Pearson, which shows the instrument content validity ratio was 0,70. This result shows that all the questions that have been arranged in this study are appropriate to be used to measure creative thinking skills. The result of instrument reliability, which was analyzed SPSS 20.00 shows that coefficient alpha Cronbach's was 0,72. This work shows that the creative thinking skills test questions in this study will give almost the same results if retested on students.

The learning stage of the experimental class used CBL implemented in STEM education integrated of CBL steps and STEM education dimensions. Learning steps for CBL of engagement (big ideas, essential questioning, challenges), guiding questions, guiding activities and resources, analysis, and act (solution, implementation, evaluation) (Nichols, Cator, & Torres, 2016). The dimensions of STEM education used in this study are Practice: Scientific Practice and Engineering Practice, Crossetting Concept, and Disciplinary Core Ideas-Physical Sciences (Pratt, 2013). The perspective used in this study is STEM education as Separate Science (Physics) Disciplines That Incorporate Other Disciplines. Both the experimental and control classes are assigned to make a design of a simple home electrical installation. The main difference is in the experimental class is to make a prototype of simple home electrical installation performance. Engineering design activity required students' to apply their understanding of physics, mathematics, and technology in doing projects.

Table 2 Data on the results of score analysis for pre test average, post test, and n-gain

Class	Score Maximum	Average Score			Criteria
		Pretest	*Posttest*	*N-Gain*	
Experi-mental	36	3.52	26.39	0.70	High
Control	36	6.36	21.45	0.50	Medium

Table 3 Normality test results gain score creative thinking skills

Data Source	Class	Shapiro-Wilk			Decision
		Statistic	*df*	*Sig.*	
N-Gain	Experiment	0.820	23	0.001	Abnormal
	Control	0.961	22	0.505	Normal

The enhancement of students' creative thinking skills is known by analyzing normalized gain (<g>) on the experimental group and control group as seen in Table 2. Furthermore, to examine the differences in creative thinking skill improvement, the data were processed with IBM Statistics SPSS 20 software. In comparing the two groups, effect size CohensKappa (d) can be computed by subtracting the mean of the second group from the mean of the first group and dividing by pooled standard deviation of both groups. Besides, to get information about students' respond toward implementation of CBL implemented in STEM education, the researcher gave a questionnaire to the students and analyzed percentage and its interpretation from every statement that was given.

3. RESULT AND DISCUSSION

Analysis of the differences in the improvement of creative thinking skills seen from the comparison of students' pretest and posttest scores analyzed using assessment rubrics adapted from Hwang et al. (2007). The category of improvement of students' creative thinking skills is determined by calculating the normalized gain (N-Gain) then interpreted by the criteria of Hake (2002). Calculation of N-Gain creative thinking skills of the experimental class is 0.70 with high criteria, and N-gain creative thinking skill of the control class is 0.50 with medium criteria. It can be concluded that the experimental class students experienced higher creative thinking skills compared to the control class students.

The effectiveness of CBL implemented in STEM education to improve creative thinking skills in learning can be determined by statistical test analysis and impact measure testing. The data used for this effectiveness analysis is the student N-Gain score data in the experimental class and the control class. Data from the normality test conducted on the N-Gain score for the experimental class and the control class have significance values of 0.001 and 0.505 as seen in Table 3. Because the N-Gain data for one of the classes pre-test-post, homogeneity tests were not carried out and continued with

Table 4 Mann-Whitney gain test results

Data Source	Class	*Sig.*	Decision
N-Gain	Experiment	**0.000**	There are significant differences

Table 5 Results of the size analysis of the impact of creative thinking

Data Source	M_E	M_C	SD_E	SD_C	SD_{pool}	d_{cohen}	Criteria
N-Gain	0.70	0.50	0.08	0.14	0.113	1,76	Great

the hypothesis test using non-parametric statistical tests Mann-Whitney U as seen in Table 4. Hypothesis test results show that CBL implemented in STEM education can improve creative thinking skills students are significantly compared to CBL combined with worksheets PSL. The results of the analysis of the impact size show that the coefficient of impact size of the application of CBL implemented in STEM education to increase students' creative thinking skills is 1.76 with large criteria as seen in Table 5. This shows that the application of CBL implemented in STEM education has a large impact on improving students' creative thinking skills compared to the application of CBL combined with worksheets PSL.

Similar research related to the application of STEM in learning shows the application of STEM can improve creative thinking skills (Furner & Kumar, 2007; Henriksen, 2014; Chasanah, Kaniawati, & Hernani, 2017; Lestari, Sarwi, & Sumarti, 2018; Ugras, 2018). The effectiveness of the STEM approach in improving students' creative thinking skills is indicated because of the following:

1. Interdisciplinary integration of elements of STEM education (science, technology, engineering, and mathematics).

Awang and Ramly (2008) mention that students will acquire creative thinking skills when they handle a complex, interdisciplinary problem and is related to real situations or everyday life. This interdisciplinary meaning certainly leads to the integration of the STEM approach that is applied in learning in experiment class.

2. Integration of STEM (Engineering Practice) education dimensions which are specifically emphasized more through project activities.

Osman, Hiong, & Vebrianto (2012) explain that the core of engineering activities (projects) is problem-solving inventively or inventively. Inventive thinking includes self-direction, curiosity, creativity, risk-taking, and higher-order thinking and sound reasoning skills. The treatment given in the in-class experiment is conducting an experiment to prove the prediction of the proposed installation in the form of project work. Through constraints and shortcomings of the solutions proposed during the project work process, students will be better trained to think creatively. The control class students are only asked to submit ideas for problem-solving, without having to design

designs and make prototypes of energy-efficient homes in real terms.

4. CONCLUSION

The results of the analysis and discussion are the difference in increasing students' creative thinking skills between the application of CBL implemented in STEM education and CBL combined with worksheet PSL known from the N-Gain calculation. The N-Gain calculation of the experimental class is 0.70, with high criteria and the N-Gain of the creative thinking skills of the control class is 0.50 with moderate criteria. The application of CBL implemented in STEM education experienced an increase in creative thinking skills higher than CBL combined with worksheet PSL. The effectiveness of applying CBL implemented in STEM education in improving creative thinking skills is seen from an analysis of the impact size. Analysis of the size coefficient of the impact of applying CBL implemented in STEM education to increase students' creative thinking skills by 1.76 with significant criteria. This result shows that the application of CBL implemented in STEM education is more effective and has a significant impact on improving students' creative thinking skills compared to application CBL combined with worksheet PSL. As an implication in order to improve creative thinking skills, learning done in class must teach knowledge, intelligence, experience, and practice. One approach that can support these activities is STEM education. The application of CBL implemented in STEM education can be carried out sustainably, either by following the learning curriculum set by the government or by modifying learning development.

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