Journal of Educational Science and Technology
Volume 5 Number 3 December 2019 page 260-267
p-ISSN:2460-1497 and e-ISSN: 2477-3840
DOI: https://doi.org/10.26858/est.v5i3.10899

The Implementation of PBL Integrated With STEM in the Material of Temperature and Its Changes to the Improvement of Students' Creative Thinking Skills and Learning Results

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(***Received***: October-2019; ***Reviewed:*** November-2019; ***Accepted:*** November-2019; ***Avalaibel Online***: December 2019; ***Published:*** December-2019)

ABSTRACT
This study aims to determine the effect of implementing PBL integrated with STEM in the materials of temperature and its changes in creative thinking skills and learning outcomes. The research method was a quasi-experimental research design with non-equivalent pretest and posttest control group. Samples were selected by purposive sampling technique. Data collection instruments were creative thinking skills and knowledge tests. The analysis technique was a different test (t-test) to determine differences in the ability to think creatively and learning outcomes aspects of knowledge, and the N-gain test to determine the effectiveness of the learning method applied. The results of this study indicate that: (1) there were differences in learning outcomes and creative thinking abilities between the control and the experimental classes (2) the effectiveness test identified that the science learning using PBL integrated with STEM is quite effective in increasing the ability to think creatively.

Keywords: *PBL, STEM, Temperature and its change, Learning outcome, Creative thinking skills*

INTRODUCTION

The 21st century is experiencing the fast and dynamic development of science and technology. In facing the era, some thinking skills required include creativity, logic, critical, and the ability to communicate (Murti, 2013). Education in Indonesia applies the 2013 Curriculum. Ideally, the teaching process based on that curriculum focuses on students, is contextual, enjoyable, and challenging so that students can boost their creativity. In other words, learning should not be limited to the process of delivering information from teachers to students. Indeed, there should be the active involvement of thinking skills during the learning activities (Astuti, S., Danial, M., & Anwar, 2018). The students' thinking skills can build learning concepts like creative and critical thinkings.

The workforce needs qualified human resources characterized by e.g. creative, productive, innovative, and actively involved in society and nation (Hariyadi, S., Utomo, T., & Wahyuni, 2014). One of the characteristics of high-quality human resources is the ability to think creatively. The ability to think creatively is a source of power, energy, and strength to carry out research, discovery, development, investigation and exploration of new things and innovations in the field of science and technology (Ghufron & Rini, 2014). The high level of creative thinking will create and bring up ideas, innovations, ideas, concepts or knowledge and even technology.

One of the strategies that can be applied to improve the ability to think creatively is education. Learning before starting class needs to be designed so that the educational objectives stated in the 2013 curriculum can be achieved. The implementation of the 2013 curriculum can be integrated with STEM (*science, technology, engineering, and mathematics*). The integration of STEM in the national learning is believed able to bring positive impacts to the activities and the output of learning. Also, it can improve teachers' motivation (Murwianto, S., Sarwanto, 2017). Broadly speaking, the application of STEM is believed possibly to connect between schools, communities and the working world (Tsupros, N.R. Kohler, 2009). The STEM learning help students to solve problems, to withdraw conclusion, and to apply the knowledge they acquire through science, technology, engineer, and math (Lou, Shi-Jer, Yung-Chieh Chou & Shih, 2017) (Budi Astuti, 2018).

Some teaching models can be applied when integrated with STEM (Carter, 2013) e.g. PBL, PjBL, and Contextual. *Problem Based Learnin*g (PBL) is one of the teaching models that is recommended in the 2013 curriculum. *Problem Based Learning* is a learning method which is based on problems and focuses on activities like inquiry, thinking, solving and understanding leading to the improvement of students' learning result and creative thinking skills (Arends, 2012).

The application of PBL in the learning activities at school has been commonly carried out by teachers yet the integration of STEM has not been well developed especially the one focusing on the improvement of creative thinking skills. The use of the PBL approach will produce higher learning results compare to the conventional learning model. PBL which is integrated with STEM can be applied in teaching science at school.

Science is a compulsory subject at Junior High School Level. Science (Trianto, 2010) is the subject that contains structural and systematic concepts and their applications are limited to phenomena happening in nature. It is identical to scientific methods including observation, an experiment that depends on a scientific attitude like curiosity, honesty, and others. This subject is often perceived as complicated by students. One of the material in the science subject which is generally regarded as difficult is temperature and its changes (Sirait, 2010) (Lestari, P. & Linuwih, 2014). The concept of temperature and the changes tend to be abstract thus leading to various interpretations in students' minds when studying it. Students generally find it difficult to build a concept, to carry out the mathematical calculation, and to withdraw conclusions of problems based on analysis (Ma'rifah, 2016). Based on the interview carried out with a teacher, it was found some facts that the material about temperature and its changes were perceived difficult. It is proved by students' daily test results. The completeness had no reached 20%.

Observation and interview conducted in a Junior High School in Surakarta stated that the school has implemented the 2013 Curriculum, yet had not fully applied the teaching approach based on the demands in that curriculum. The teaching of science still focuses on the teacher. It was seen when we conducted an observation of the learning process. Teachers were very active in the teaching process by transferring the knowledge to students, and even data obtained from interviews carried out to both teachers and students confirmed that teachers are too active in the classroom instead of being as facilitators only. Besides the teaching activities which are dominated by teachers, the learning resources were also limited. Students only had textbook lent by the school. That learning resource is regarded to be ineffective to stimulate students' activeness in studying. Ideally, learning activities should actively involve students.

The existing teaching activities have not optimally integrated STEM into their daily lives. It needs to design a teaching approach that can engage students to involve actively by considering issues in the real world integrated with science, technology, engineering, and mathematics and can improve the skills demanded in the 21^{st} century especially about creative thinking. Based on that explanation, this study aims to investigate the effect of Problem Based Learning integrated with STEM on the improvement of students' creative thinking and learning results.

METHOD

This study employed a quasi-experimental approach with a non-equivalent pretest and posttest control group design (Cresswell, 2014). There were two classes involved in this study namely control and experimental classes. The experimental group taught science by applying the Problem Based Learning method integrated with STEM while the control group used the conventional teaching method. The research design is presented in Table 1.

Tabel 1. Desain penelitian non-equivalent pretest and posttest control group

Classes	***Pretest***	***Treatment***	***Posttest***
Esperimental	O_1	X	O_2
Control	O_3		O_4

Source: (Sugiyono, 2012)

Annotation :
O_1 = Data about students' initial ability at experimental class
O_2 = Data about students' final ability at experimental class
O_3 = Data about students' initial ability at control class
O_4 = Data about students' final ability at control class
X = *treatment*

This study was carried out in a state junior high school in Surakarta in the academic year of 2019/2020. The research populations were al students at VIIA-VIIG classes (200 students) in the academic year of 2019/2020. Samples were selected using *a purposive sampling* technique. The samples were 32 students from each class VIID and VIIE. Class VIIE was the experimental group while class VIID was the control group.

The instrument to assess the creative thinking skill referred to indicators of creative thinking skills by (Ismaimuza, 2010). The students' creative thinking skills were assessed using a written test with five essay questions. The instrument has been validated by 2 expert lecturers and 2 education practitioners (Science teacher). The result of the trial was processed using Anates Software for essay questions before implemented to control and experimental classes. The result of validation performed by expert lecturers and educational practitioners showed the instruments reliable and valid to use. The results can explain that the creative thinks skills test that would be used can identify and assess students' creative thinking based on the criteria that we referred to. Test of learning result (knowledge aspect) consisted of 25 questions that were processed using items to know the validity, reliability, discrimination power, and its difficulty level.

Data that were obtained from the pretest and posttest were quantitative. They were analyzed using normalized gain (*N-gain*) and discrimination power tets. The normalized gain aimed to know the improvement of students' creative thinking skills before and after treatment. *Gain score/ N-Gain* refers to the difference between pretest and posttest scores.

The gain score (Meltzer, 2002) can be obtained from the following equation:

$$N\text{-}Gain = \frac{T\ post - Tpre}{T\ maks - T\ pre}$$

Annotation :
T post = the average *posttest* score
T pre = the average *pretest* score
Tmax = maximum ideal score

The Gain scores which had been obtained were analyzed based on their category as in the table of gain score interpretation.

Table 2. Categories of N-Gain Scores

Scores <g>	**Categories**
$(g) \geq 0.7$	High
$0.3 < g \leq 0.7$	Medium
$(g) \leq 0.3$	Low

Source : (Meltzer, 2002)

Teaching through PBL integrated with STEP is perceived effective to the improvement of learning results related to knowledge and creative thinking aspects when the *N-Gain* value is in the medium category which in this case, the score of <g> is between $0.3 < g \leq 0.7$. Those data were analyzed with statistic tests including normality, homogeneity, and t-tests (*Independent Samples T-Test*) using IBM SPSS 20 software. In this statistical test, we used significance level (α) of 0.05 or 5%/ The decision is taken if Sig (*2-tailed*) < 0.05 meaning the H_0 is refused while H_1 is accepted (Siregar, 2013).

RESULT AND DISCUSSION

Result

1. Learning Results

The following table (3) shows the categorization of *N-gain* value of knowledge aspects.

Table 3. The categorization of *N-Gain* from the learning results (knowledge aspects)

Classes	***Pretest***	***Posttest***	***N-Gain***	**Categories**
Control	35.94	57.94	0.3243	Medium
Experimental	27.25	68.13	0.5637	Medium

Next, the improvement of learning results is presented in the graph below.

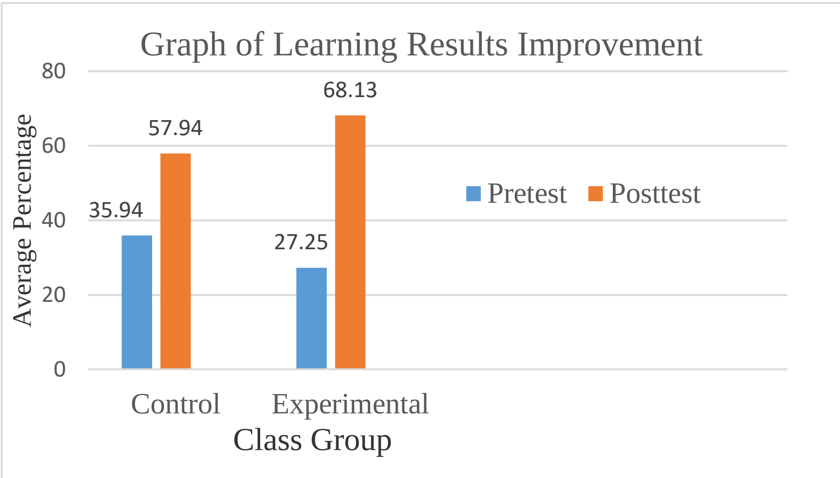

Figure 1. Graph of Learning Result Improvement

Table 4. Results of Statistical Test on Learning Results

Tes	***Pretest***		***Postest***	
	Control	Eksperimental	Control	Eksperimental
Normality	0.163 (Normal)	0.161 (Normal)	0.67 (Normal)	0.56 (Normal)
Homogeneity	*Sig 0*.195 (Homogenous)		*Sig* 0.892 (Homogenous)	
The T-test (*independent sample t-test*)	*Sig* 0.055 (There was no significant difference)		*Sig* 0.004 (There was a significant difference)	

2. Creative Thinking Skills

Table 5 below depicts the categorization of *N-gain* scores of creative thinking skills.

Table 5. The categorization of *N-Gain* score of creative thinking skills

Classes	***Pretest***	***Posttest***	***N-Gain***	**Categories**
Control	36.09	45.31	0.1223	Low
Experimental	40.16	69.69	0.4724	Medium

Then, the graph of the improvement of creative thinking skills is shown below.

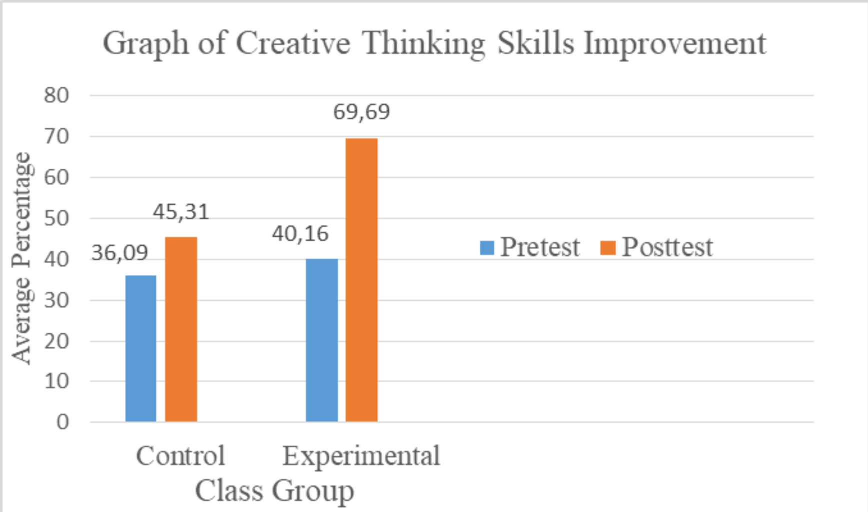

Figure 2. The Graph of Creative Thinking Skills Improvement

Table 6. Results of Statistical Test of Creative Thinking Skills Data

Test	***Pretest***		***Postest***	
	Kontrol	Eksperimen	Kontrol	Eksperimen
Normality	0.200 (Normal)	0.122 (Normal)	0.200 (Normal)	0.181 (Normal)
Homogeneity	*Sig 0*.411 (Homogenous)		*Sig* 0.092 (Homogenous)	
the t-test (*independent sample t-test*)	*Sig* 0.354 (There was no significant difference)		*Sig* 0.000 (There was a significant difference)	

Discussion

Learning Result

In this research, we only analyzed the knowledge aspect. The N-gain of pretest and posttests data that has been measured as presented in Table 3 showed that the control class was 0.3243 while the experimental class was 0.5637. Both classes were in the medium category. The results indicated that the implementation of problem-based learning integrated with STEM in teaching science can improve students' learning outputs. The improvement of pretest and posttest scores can be seen in figure 1. The average increase in the control class was 22 while in the experimental class it was 40.88. compared to the improvement in the experimental class, the improvement in the control class was lower. Therefore, teaching science by implementing problem-based learning integrated with STEM can increase the students' learning output.

The effectiveness of Problem Based Learning integrated with STEM was measured by carrying out normality (*Kolmogorov-Smirnov*) and homogeneity tests (*Levene test*) continued with the T-test. The analysis results are presented in Table 4.

Based on Table 4, the pretest and posttest data of both classes were normal and homogenous. The t-test of pretest scores showed *sig* 0.055 (*sig*>0.05), indicating that students' ability before the research was similar. It was different from the t-test of the posttest score which showed *sig* 0.004 (*sig*<0.05). It indicates that there was a significant difference in students' skills after the treatment. In other words, there was a difference in the learning results of students at the control and experimental groups.

Based on those findings, it can be concluded that PBL integrated with STEM can improve the students' achievement in knowledge and thinking aspects. This finding is in line with (Orhan, A. & Ruhan, 2007) stating that PBL can bring positive effects to academical achievements. Another study (Murwianto, S., Sarwanto, 2017) supporting this current research stated that there is a positive impact on the use of STEM on the learning result. Problems presented in PBL learning integrated with STEM can stimulate students' interaction when tracking and solving them which at the end can increase students' cognitive performances (Irawan, 2010).

The finding of the previous study did not show any aspects that got positive impacts from the implementation of PBL integrated with STEM. This research exclusively showed a positive impact on learning achievement related to knowledge acquired by students. PBL integrated with STEM stimulates students' active participation in building knowledge-based on problems generally found in their daily lives. Problems presented in PBL integrated with STEM challenges students to seek solutions integrated with various related and important disciplines like science, technology, engineering, and math.

Creative Thinking Skills

Based on the categorization of *N-gain* scores, as presented in Table 5, we identified the control class got 0.1223 (low) and the experimental class was 0.4724 (medium). Based on the results of pretest and posttest measured based on their *N-gain*, teaching science by implementing PBL integrated with STEM shows improvement in the ability to think creatively. The increase of the experimental class' score was 29.53, while in the control class, it increased by 9.22. It indicates that the improvement of control class' scores was as high as the experimental class. In other words, teaching science by implementing PBL integrated with STEM can boost students' creative thinking skills.

Based on Table 6, data of pretest and posttest of control and experimental classes were normal and homogenous. Then, we carried out a t-test` that resulted in *sig* 0.354 (*sig*>0.05), which means that the students' initial abilities were similar. While the t-test carried out on the posttest scores showed *sig* 0.000 (*sig*<0.05), indicating that there was a significant difference in students' creative thinking ability. The statement implies that there is a significant difference in students learning results after given treatment in both control and experimental classes indicated by their posttest scores.

Based on the study findings, it can be concluded that teaching science with the PBL model integrated with STEM can improve creative thinking skills. This study is in line with (Siswono, 2011) (English, L.D., & King, 2015) that the implementation of PBL has a positive effect on students' creative thinking skills. It allows students to understand the problem. The emergence of that understanding indirectly engages them to get ideas and solutions for the problems.

Another study (Irawan, 2010) supporting this current research concluded that the implementation of teaching based on the problem can improve students' creativity. Through teaching method which integrates science, technology, engineering and math in solving problem found in the real world, students thinking skills can be improved thus have their potential, in general, can be improved too, so as the nation (Sukma, 2018).

Based on the finding of this study, it can be seen the application of PBL integrated with STEM is effective to boost students' creative thinking skills compared to the teaching with the conventional approach or without the integration of STEM. The integration of STEM in teaching is regarded as possible to challenge students to face real problems so that in the long run, they will become individuals with good qualities including the ability to think creatively in solving problems in the real world.

The implementation of STEM in teaching should be maximized considering that the 21st century is dominated by the rapid development of technology and knowledge. Education should adapt to the development of technology to create humans who can compete in the global work world. Besides that, students are demanded to change dynamically based on the development of the era, The integration of STEM into the problems found in the real world will enable teachers to be more innovative and motivated in carrying out the teaching activities.

CONCLUSION AND SUGGESTION

The findings of this study show that: (1) there is a difference between the learning output and creative thinking skills between students in the control and experimental classes; 2) the effectiveness test indicates that teaching science through PBL model integrated with STEM is effective to increase the creative thinking skills.

PBL integrated with STEM is expected to be implemented in all subjects to make them more structured and well-directed, and STEM should be more developed with various innovations on the learning model. Hopefully, this current research can add the innovations of teachings that integrate their approach with STEM.

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