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STEM-PjBL: Its effect on students creative thinking skill in environmental pollution material

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ABSTRACT

Teaching and learning in the 21st century should equip students with creative thinking skills to be ready to live and contribute productively to society. This study aims to determine the effect of the implementation of STEM-PjBL on Creative Thinking Skill in Environmental Pollution Material of 7-grade. The quasi-experimental design of the nonequivalent pretest-posttest control group was used in this study. The subjects in this study were students of class VII at SMP Negeri 37 Medan. Subject selection was done by purposive sampling technique. The samples of this study consist of class VII-D as the control class and class VII-C as the experimental class. Data collection techniques used in this study were test techniques. The instrument used was the multiple-choice questions consist of 25 questions to measure student learning creative thinking skill based on the Tawil and Liliasari from Building The Knowledge, Arouses Curiosity, Looking at The Different Angle of Information and Forecasting Limited Information. This means that there is an effect for learning between the experimental class and the control class. The average result of the student creative thinking skill in the experimental class was 91% (very good category). The results showed that there was a significant effect of the STEM-PjBL Model on Students Creative Thinking Skill learning was in 0.030 for effect learning with t-test and this is the results of the t-test obtained that the 2-tailed significance value, the STEM-PjBL model can be used as an alternative learning to empower 21st century skills.

Keywords: Creative thinking skill, environmental pollution, STEM-PjBL model

INTRODUCTION

Growing awareness of the environment in the world of education is very important. Awareness is an important element in the living environment that everyone, including students and prospective teachers, must have. Students must be aware because they are the next generation who will protect the environment in the future (Si et al., 2022; Wibowo et al., 2024).

Teacher creativity in designing learning on environmental pollution material is necessary to increase students' awareness of the importance of protecting the environment. So far, learning has still focused on cognitive abilities (Utaya & Wafaretta, 2021). Learning activities that take into account creative thinking abilities can be done giving birth to something new, either in the form of ideas or real work in learning science, namely by using appropriate learning models. or this reason, a learning model is needed that can foster students' creative thinking skills so that learning does not only target cognitive ones.

Creative thinking skills have a relationship with science process skills. It produces productivity achievements that contain components of science process skills (Demir & Sahin, 2018 ; Rizal et al., 2022). Grow creative thinking skills in students can stimulate science

process skills such as observing, predicting, and making hypotheses, so that they think creatively help students master better science process skills (Yildiz & Guler Yildiz, 2021; Fatmawati, Jannah & Sasmita, 2022).

Creative nature will grow in children if they are trained, accustomed to exploring and looking for new things that are exploratory by adding understanding and responses and solving problems (Rahmah, Azmin & Nasir, 2019; Zain, Sailin & Mahmor, 2022). Although creativity can be developed through practice, in fact in science learning, the learning process in the classroom is still directed to the skill of memorizing information, while high-level thought processes including creative thinking are still rarely trained. This achievement is certainly the result of learning conditions that are still conventional and have not yet developed fostering student creativity, namely how to actually learn (Amiruddin et al., 2021).

Conventional learning methods are a major factor compared to other factors that influence students' difficulty in developing creative thinking skills. It is necessary to increase the potential of human resources from the individual side in the era of Information Technology, and among the benefits is learning by applying STEM learning (Suwardi, 2021; Hacioğlu & Gülhan, 2021).

The results of a preliminary study at SMP Negeri 37 Medan showed several problems in learning, especially in the science learning process on environmental pollution material, this was because teachers who taught environmental pollution material still used conventional learning, never carried out practicums, and did not use learning media. This can be seen when the teaching and learning process takes place, teachers dominate the class more and provide less opportunities for students to come up with ideas in the learning process, teachers always play an active role, while students tend to be passive, resulting in students being less active in the process. learning, as well as the results of interviews with several students regarding actions to care for the environment, they do not yet have adequate actions to care for the environment.

Science has a strong structure and relationship between concepts that allows students to be skilled in rational thinking and thinking actively with ideational skills, so that if students can understand science learning well, it can equip students to think creatively in solving problems that occur in the surrounding environment (Akhiril, 2014). Creative thinking has a higher level than critical thinking. Creative thinking skills must have critical thinking skills. People who have creative thinking skills or often also called divergent thinking have high creativity and are beneficial to many people. Therefore this creative thinking skill is very important to be taught in schools (Lombard et al., 2020; Septiany et al., 2024). The ability to think creatively is the ability by which students generate new ideas resulting from new understandings So that students who have the ability to think creatively was able to find solutions in a new way.

A learning model that can be applied is the STEM Project-Based Learning model. Through the learning approach that was carried out, namely STEM, it is very useful to improve students' creative thinking skills by encouraging students to discover and explore new things and information that encourage students to actively ask questions and opinions in class and the projects carried out (Dewi, Arnyana & Margunayasa, 2023; Indahwati, Rachmadiarti & Hariyono, 2023).

An interactive approach taken with the application of various fields of science, namely STEM. STEM which consists of elements of Science, Technology, Enginering and Mathmatics is based on learning with the proximity carried out is able to collect and analyze problem solving and relationships between problems (Khoiriyah & Husamah, 2018; Kartini et al., 2024). The PjBL Learning Model will make students develop projects on related materials so that they are able to develop students' creative thinking skills. In STEM-PjBL learning, students are invited to do meaningful learning in understanding a

concept. Students are invited to explore through a project activity, so that students are actively involved in the process (Roslina, Samsudin & Liliawati, 2022; Lou et al., 2017). Several researchers have conducted studies related to the implementation of STEM learning, PjBL, and discovery learning in science education. Recently, Shanta and Wells (2020) found that technology-based learning and engineering design significantly affect students' creatice skills.

The environmental pollution material contained in class VII junior high school has a relationship with the project learning model because students are able to connect information with information from different disciplines, which is triggered by students' curiosity and curiosity about the environment and existing pollution. Real-life-based learning activities assist students in realizing the importance of theory and science in natural resource management. applied to the inside Because of the written communication skills in the content and writing language, students can write down an idea of the right solution to overcome the problem of environmental pollution. In the learning process, the teacher guides students in small groups to develop various solutions to given problems, encourages collaborative learning and strengthens critical thinking, creative and communication skills (Sumarni, Wijayati & Supanti, 2019; Pertiwi, Oetomo & Sugiharto, 2024).

The results of previous research for learning with the STEM-PjBL Model can improve critical thinking skills, especially the creative skill namely in the research of Furi et al., (2018), namely learning with the STEM-PjBL model with learning with product formulation and design that has been carried out by students to bring out creative ideas of students, design work procedures that was carried out by making process diagrams, designing the resulting development processes and products. Based on research by Widarti, Rokhim and Syafruddin, (2020); Purwaningsih et al., (2020), the advantages of the STEM-PjBL learning model are 1) students are more challenged in the learning process; 2) students make observations enthusiastically; 3) increase understanding of actual concepts; 4) student interaction increases; 5) creativity in developing projects

Research conducted by Fitriyah and Ramadani (2021) states that learning the Project-Based Learning model with a STEM approach has a significant effect on creative thinking skills by exploring through a project activity, so that students are actively involved. PjBL learning is learning that uses comprehensive learning with the design of the student learning environment or classroom atmosphere to investigate problems to learning materials and carry out learning tasks.

From some of the literature above regarding the influence of STEM-PjBL on students' level of creative thinking, there has been no research conducted in schools that would launch an adiwiyata school. It is hoped that this research can raise students' awareness of environmental concerns at SMP Negeri 37 Medan to support the realization of adiwiyata-oriented schools.

METHOD

This research is a Quasi-Experiments with Nonequivalent Pretest-Posttest Comparison Group Design (Best & Kahn, 1995). There are two groups involved, namely the experimental group and the comparison group. The two groups were given different treatment where the measurement of creative thinking skills was carried out before (pre-test) and after (post-test) treatment. The design of this study is shown in Table 1.

Table 1. Pretest – Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experimental Class (VII-C)	O_1	X_1	O_2
Control class (VII-D)	O_3	X_2	O_3

Note:
O_1: The observation of the experimental class pretest; O_2: The result of the experimental class posttest;
O_3: The observation of the control class pretest;
O_4: The observation of the control class posttest;
X_1: The experimental class treatment;
X_2: The control class treatment.

The subjects in this study were students of class VII at SMP Negeri 37 Medan who had received the environmental pollution material. Subject selection was done by purposive sampling technique. The samples of this study consist of class VII-D (31 students) as the control class and class VII-C (32 students) as the experimental class. The control class carried out conventional learning, while the experimental class with the STEM-PjBL model Learning. Subject selection was done by purposive sampling technique. The samples of this study consist of class VII-D (31 students) as the control class and class VII-C (32 students) as the experimental class. The control class carried out direct instruction learning, while the experimental class with the STEM-PjBL model Learning.

This study used an instrument in the form of a test in the form of multiple choice. The test instrument was used in the form of a question test conducted at the beginning of learning (pretest) and at the end of learning (posttest). The results of the analysis of the validity and reliability of the instrument can be seen in Table 2.

Table 2. The results of validity and reliability instrument

Type of Validity/ Reliability	Method Used	Results
Content Validity	Assessment by 2 experts	All items are considered relevant to the question indicators
Construct Validity	Product Moment correlation coefficient	The table r value for N=32 with a significant level of 0.05 is 0.34. Of the 50 multiple-choice questions, 27 questions were declared valid and 22 questions were declared invalid
Reliability Test	the Kuder Richarderson formula (KR-20)	From the calculation of the reliability test, it can be stated that rs > r_{table} (0.79>0.34). From the results of these calculations, it can be stated that the question is reliable with a high category

The data in this study were students' creative thinking scores obtained from the pretest and posttest results. Data were tested using descriptive statistics and inferential statistics. The normality and homogeneity tests of each of the pretest and posttest results were carried out be fore testing the hypothesis.

RESULTS AND DISCUSSION

The normality test results of the experimental class pretest and posttest data and the control class pretest and posttest. The sig value of the experimental class pretest learning results is 0.20 and the experimental class posttest is 0.13. The normality test results for the creative thinking ability data of experimental pretest students were 0.20 > 0.05 and the experimental class posttest data were 0.13 > 0.05 so that the experimental class pretest and posttest learning outcomes data were normally distributed.

After the data tested for normality and normally distributed, it was continued with the homogeneity test. The homogeneity test is a test that shows each variable has homogeneous or inhomogeneous variations. The basis for decision making if the sig value > α (0.05) then homogeneous, on the contrary if the sig value < α (0.05) then it is not homogeneous. The significant value is 0.23 > 0.05 so that it can be decided that from the homogeneity test that has been tested it can be concluded that the variation of each variable both from the experimental class and the control class is homogeneous.

After the data is tested for normality and homogenity, it is continued with the hypothesis test. The hypothesis test is a test that aims to see whether or not the STEM-PjBL learning model skills the ability to think creatively of students. In this study, the tests carried out were Independent Sample t-Test with the help of SPSS Type 25 version 25.

The basis for decision making if the sig value > 0.05 then H0 is accepted and Ha is rejected, conversely, if the sig value < 0.05, then H0 is rejected and Ha is accepted. Based on the calculation results of the hypothesis test above, significant value data (2-tailed) of 0.03 was obtained. So it can be stated that 0.03 < 0.05 so that a decision can be made that H0 is rejected and Ha is accepted. Independent sample t-Test for effect of the STEM-PjBL Model Learning, is shown in Table 3.

Table 3. Independent sample t-test for effect of the STEM-PjBL Model Learning.

	t-test for Equality of Means						
	t	df	Sig (2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
						Lower	Upper
Equal variances assumed	2.227	61	0.030	5.85988	2.63123	0.598	11.121

Based on the calculation results of the hypothesis test above, significant value data (2-tailed) of 0.030 was obtained. So it can be stated that 0.037 < 0.05 so that a decision can be made that H0 is rejected and Ha is accepted. Thus, it can be concluded that the STEM-PjBL learning method is effectively used in science learning on students' creative thinking skills in Environmental Pollution material in grade VII of SMP Negeri 37 Medan for the 2022/2023 academic year.

There is an increase in high category learning outcomes using the STEM- PjBL learning model because at the stage of the learning model learning activities involve all students to be active and work collaboratively in groups to complete projects. Comparation between pretest and posttest the two class, is shown in Figure 1.

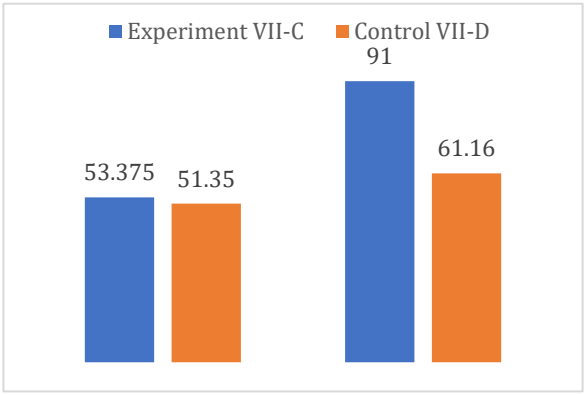

Figure 1. Comparation between pretest and posttest of the two classes.

Based on Figure 1, it can be seen that none of the experimental classes and control classes of students' pretest scores can achieve KKM scores. In the experimental class, the lowest pretest score was 48 and the highest score was 72 with a student pretest average score of 53.375. While in the control class, the lowest pretest score was 44 and the highest score was 60 with an average score of 53.35. The low results of student pretest learning are understandable because students have not received learning about Environmental Pollution material so that students do not understand and know the Environmental Pollution material at all. It can be seen that the experimental class has a posttest score with the lowest score of 84 as many as 9 students and the highest score of 100 as many as 4 students. With an experimental class posttest average score of 91. While in the control class, the lowest score was 60 as many as 9 students and the highest score was 74 as many as 3 students.

The students result of the students creative thinking skil using STEM-PjBL model learning of environmental pollution higher compared to the creative thinking skill using direct instruction learning can be seen from critical thinking indicators according to Tawil & Liliasari (2013).

a. Building on the knowledge students already have

STEM-PjBL stage starting from planning to making project which lets the studets to use material and tool (techological aspect), arranging solution (engineering aspect), and communicating the result in a table/ graphic (mathematics) gives a direct meaningful sciences

learning. In the learning that has been carried out in both classes, namely the experimental class and the control class with differences in the learning model used, indicators of creative thinking ability in students in the experimental class have a significant comparison skills creative thinking of students allow individuals to establish healthy interpersonal relationships and skills others in a positive way around them (Erlinawati, Bektiarso, & Maryani, 2019; Hasibuan et al., 2022).

b. Arouses curiosity

Direct and meaningful learning because of research and discovery activities by finding out and exploring existing information as well as activities related to environmental problems that are around. Students have done something like accepting a challenge from problems, planning a problem solving strategy, implementing strategies, and retesting solutions obtained. In STEM-PjBL learning these activities are in the putting together an idea project (Cahyani, Mayasari & Sasono, 2020; Aisyah & Rosnita, 2021).

c. Looking at different angles of information

As stated by Afriana, Permanasari and Fitriani (2016), PjBL for STEM education is an interesting and effective way to conceive implementation of technology and engineering in the classroom. In STEM-PjBL learning in the classroom, students also improved the ability to see information in each problem by correlating each problem around with human activities that can damage the environment. In addition, learning with the implementation of STEM in existing worksheet, namely in experiment activities and projects made students able to see information more clearly. Compared to control class, learning stage in STEM-PjBL Model had not integrated STEM (Alkautsar et al., 2023).

d. Forecasting limited information

Work that has been carried out by both classes, the results of the experimental class group were higher than the control class because only the experiment class met the aspects of Science, Technology, Engineering and Mathematic on environmental pollution topics. PjBL (Project Based Learning) according to Han et al., (2016) followed by compiling a Project Schedule and Monitoring Students can carry out project activities carried out by reading, researching, observing, interviewing, recording, working on the group. The student can increase motivation, can improve the ability to manage resources, and Increased resource – management skills (Siew, Amir & Chong, 2015; Nurhayati et al., 2023).

CONCLUSION

The results of this research data analysis prove that the STEM-PjBL learning model has an influence on students' level of creative thinking on environmental pollution material. The suggestions that can be given by researchers are as follows: 1. The STEM-PjBL model needs to prepare more for the science material, from good preparation, understand material, and time management learning for improving students effectiveness in its application; 2. The STEM-PjBL model needs to be analysed more for learning based on the different science topics are used in teaching to improve the quality of learning activity and learning outcomes.

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