IMPROVING MATHEMATICAL CREATIVE THINKING ABILITY OF JUNIOR HIGH SCHOOL STUDENTS WITH PROBLEM BASED LEARNING MODEL THROUGH STEM

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ABSTRACT

Pembelajaran abad 21 menggencarkan untuk menggunakan kreativitas dalam pembelajaran. Kreativitas sangat penting untuk semua disiplin ilmu dan kegiatan pembelajaran. Model PBL terintegrasi STEM dikombinasikan dalam suatu materi ajar yang disusun dengan persoalan yang disesuaikan dengan indikator berpikir kreatif matematis. Penelitian ini bertujuan untuk mengkaji peningkatan kreativitas dalam pembelajaran matematika melalui penyelesaian persoalan dengan cara yang kreatif. Metode yang digunakan adalah kuantitatif menggunakan uji-t, uji proporsi dan N-Gain. Penelitian dilakukan di salah satu SMP Negeri di Kabupaten Semarang. Secara kuantitatif diperoleh rata-rata nilai pretest sebesar 72,44 dan rata-rata nilai posttest sebesar 85,66 dan uji N-gain untuk semua indikator berpikir kreatif matematis rata-rata sebesar 0,51 dengan kategori peningkatan sedang. Indikator kelancaran mendapatkan hasil 0,38 pada kategori sedang, indikator keluwesan 0,46 pada kategori sedang, indikator keterincian 0,48 pada kategori sedang, dan indikator keaslian mendapatkan hasil 0,64 pada kategori sedang. Hasil penelitian menunjukan bahwa pendekatan pembelajaran STEM dengan model PBL dapat meningkatkan kemampuan berpikir kreatif matematis siswa melalui penyelesaian persoalan dalam materi ajar. Penerapan model PBL terintegrasi STEM dapat diintegrasikan ke dalam media atau materi sumber belajar yang interaktif dan mengintegrasikan pembelajaran STEM dapat dilakukan dengan kegiatan praktik secara langsung.

Kata Kunci*:* Berpikir kreatif matematis, PBL, STEM

ABSTRACT

21st century learning intensifies to use creativity in learning. Creativity is essential for all disciplines and learning activities. The STEM integrated PBL model is combined in a teaching material that is prepared with problems that are adapted to mathematical creative thinking indicators. This research aims to study the improvement of creativity in mathematics learning through solving problems in creative ways. The method used is quantitative using t-test, proportion test and N-Gain. The research was conducted at one of the

state junior high schools in Semarang Regency. Quantitatively obtained an average pretest value of 72.44 and an average posttest value of 85. 66 and an N-gain test for all indicators of mathematical creative thinking averaged 0.51 with a medium improvement category. The fluency indicator gets a result of 0.38 in the medium category, the flexibility indicator 0.46 on the medium category, the elaboration indicator on 0.48 in the medium category, and the originality indicator gets a result of 0.64 in the medium category. The results showed that STEM learning with the PBL model can improve students' mathematical creative thinking skills through solving problems in teaching materials. The application of stem integrated PBL models can be integrated into interactive media or learning resource materials and integrating STEM learning can be done with direct practical activities.

Keywords *: Mathematical creative thinking, PBL, STEM*

INTRODUCTION

The 2013 curriculum sets the competency standards for primary and secondary education graduates on aspects of skills that are integrated with 21st century skills. 4C abilities are included in 21st century skills which are a means to achieve success in learning in the 21st century that students must possess. The 4C skills are Communication, Collaboration, Critical thinking and Problem Solving skills, and Creativity and Innovation (Erdoğan, 2019).

Students are also required to have skills, knowledge, and expertise that must be mastered in the fields of technology, media, and information (Zakiah et al., 2020). Learning in the 21st century demands learning that integrates technology.(Zakiah et al., 2020)

The ability to think creatively during the industrial revolution 4.0 is an essential skill that must be possessed by students at every level of education (Monica et al., 2021). Wijaya et al., (2021) state that mathematical creative thinking is a thingking process that produces a new solution or idea for a mathematical problem or the formulation of new questions.

According to the global innovation index 2021, Indonesia is ranked 87 out of 132 countries (Soumitra et al., 2021). Innovation is closely related to the creative thinking process, innovation is produced through the creative thinking process (Levenson et al., 2018). If the creativity index of Indonesian students is low, then good innovation cannot be expected to be developed in Indonesia.

Research by Maskur et al. (2020) in comparing Indonesian students with international students to solve creative thinking problems, Indonesia gets the lowest percentage in the aspect of reasoning. Indicators of reasoning aspects have the lowest value due to students' reasoning ability, one of which is reflected through the ability to think creatively. Comparison of students' mathematical creative thinking completion in figure 1.

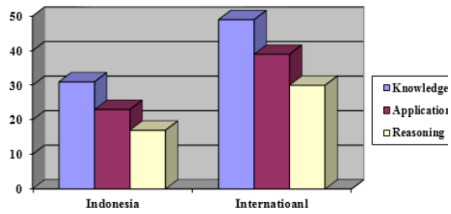

Figure 1. Indonesian and International Student Answer Results

Observations made by researchers through tests of mathematical creative thinking ability and interviews with junior high school mathematics teachers in one of the schools in semarang district showed the result that that students tended not to dare to answer questions with different answers from other friends even though the actual answer did have more than one answer. Students did not want to try to solve the problem with their own ideas, so they depends on friends who they think are smart. The average test score of mathematical creative thinking ability is below KKM. Interviews with mathematics teachers in junior high schools revealed that there are limited learning resources for students only using textbooks provided by the school, switching online to offline makes students passive, students' understanding with other students is very different, and online activities make it difficult for students to discuss with other students. or even to the teacher.

Based on these problems, learning is needed that can improve students' mathematical creative thinking skills. Students' mathematical creative thinking ability includes 4 aspects, namely fluency, originality, flexibility, and elaboration (Saironi & Sukestiyarno, 2017).

Demands of the 2013 curriculum, the learning model that can be applied is the Problem Based Learning model. PBL is a learning model that presents contextual problems that stimulate students to learn (Laforce et al., 2017). PBL fosters students' creativity in solving mathematical problems (Maulidia et al., 2019). According to the Ministry of education and culture, PBL is a learning based on a contextual problem so that it can encourage students to learn in solving problems (Sari & Hardini, 2020). PBL is expected to make students have an important role in learning or as self-directed learners, students through PBL can have creativity and innovation in mathematics learning.

In addition to the learning model, in order to keep up with the development of the 21st century, the government also suggests being able to integrate an approach. Kotseva (2019) stated that STEM is an integrated learning that combines four disciplines, technology, engineering, and mathematics into one class, unit, and lesson based on connections between subjects and real-world problems by involving STEM practices to improve the learning ability of students.

Subakti et al. (2021) stated that STEM is a discipline whose four are closely related to each other. The STEM learning approach is expected to create meaningful learning for students by systematically integrating knowledge, concepts and thinking skills into the teaching and learning process and developing student creativity through the problem-solving process in everyday life. STEM is also designed to prepare students for a highly competitive work environment that

requires competitive value skills and creativity.

According to Jolly in Erlinawati et al., (2019), STEM has six specific characteristics that distinguish it from other approaches, namely: (1) STEM learning is focused on problems that exist in the real world and find solutions to solve these problems; (2) STEM learning is guided by an engineering design process where the design comes from the students' own thoughts in developing problem solutions; (3) STEM learning involves students in productive teamwork; (4) STEM learning brings students into learning activities that are open and have limitations; (5) STEM learning integrates math and science so that students realize that science and mathematics are not isolated subjects, but rather work together to solve a problem; (6) STEM learning allows for correct answers and reframes failure as an important part of learning where STEM learning offers a wide range of possibilities for creative solutions.

The STEM integrated PBL model is a learning that is integrated with science, technology, engineering, and mathematics to increase student creativity through the process of solving problems in everyday life (Craig & Marshall, 2019).

The integration of STEM in problem-based learning is able to guide students to solve problems given in groups, thereby encouraging students to work together who are responsible for their work independently and can manage discussion patterns that are suitable for the circumstances of their respective groups (Triwahyuningtyas et al., 2020). Students can not only focus on solving mathematical problems, but also have knowledge from other sciences to solve problems contained in STEM, thus providing students with creative thinking skills so that they can polish them optimally.

DISCUSSION

The approach in this study uses a quantitative approach with Pre-Experimental as a research method in the form of one group pretest-posttest design and simple random sampling as a sample selection technique. According to Sugiyono (2010) the purpose of the quantitative method is to show the relationship between variables, test theories, and look for generalizations that have predictive values.

$$O_1 \; X \; O_2$$

Figure 2. Experimental Model with One Group Pretest-posttest Design

The research design framework in Figure 2 shows that this study began with giving pretest questions in the form of descriptions (O_1) to identify students' creative thinking skills before being given treatment, then in learning students were given PBL-STEM (X) based teaching materials. Furthermore, students are given a posttest question in the form of a description (O_2) whose criteria are the same as the pretest question so that researchers are able to identify students' creative thinking abilities after receiving treatment.

The research data was obtained through a written test method in the form of a description. Before being applied in learning, the test sheet descriptions the ability to think creatively tested for validity, reliability, differentiation power, and

difficulty level first. If the test sheet is valid and reliable then it is worth using in research.

The data analysis technique used is the paired t-test and the proportion test. Testing the data using SPSS 22.0 software. Hypothesis H_0 in this study is PBL-STEM-based teaching materials have no significant effect on increasing students' creative thinking skills, while hypothesis H_1 is PBL-STEM-based teaching materials have a significant effect on increasing students' creative thinking abilities.

The level of increasing students' creative thinking skills after participating in learning using PBL-STEM-based teaching materials can be analyzed using the N-Gain Test with the criteria for the amount of Gain according to Hake in Jusuf et al. (2019) is shown in table 1. below.

Table 1. N-Gain Criteria

The magnitude of the N-Gain factor	Criterion
$(g) \leq 0{,}30$	Low
$0{,}30 < (g) \leq 0{,}70$	Medium
$0{,}70 < (g)$	High

In this study, to determine the improvement of mathematical creative thinking skills, using a proportion test to find out whether students achieved completion above 75%, a sample paired t test (Wilcoxon Signed Rank) to find out whether there were differences in the value of pretest and posttest learning outcomes in the STEM integrated PBL model, proportion test to know classical completeness and the N-Gain test to determine the effect of applying the STEM integrated PBL model.

Paired sample t-test was conducted to determine whether there was a difference in the scores of pretest and posttest learning outcomes in the STEM-integrated PBL learning model.The data of the results of the T test are presented in the following table 2.

Table 2. Paired Sample T Test Results

Paired Samples Test			
	t	Df	Sig. (2-tailed)
Pair 1 Pretest-Postest	-11.180	35	.000

The results of the paired sample T test showed that the value of $sig.(2-tailed) = 0{,}000 < \alpha = 0{,}05$. Based on the normality test criteria, H_0 is rejected. It can be concluded that there are differences in the students' pretest and posttest scores. The students' average pretest scores were 72.44 and the students' posttest averages were 85.66. The following diagram shows the results of the students' pretest and posttest scores.

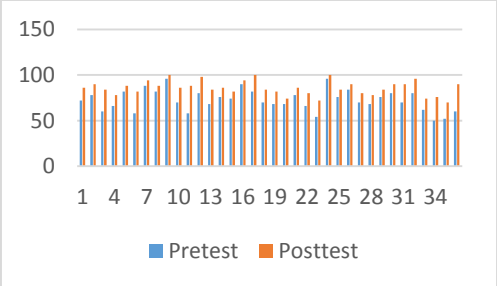

Figure 3. Student Grade Results

Based on the results of the paired sample t-test, Sig value = 0.000 (< 0.05) was obtained. So it can be concluded that by giving treatment, namely with a STEM

integrated PBL learning model during the learning process, it can improve students' mathematical creative thinking skills. The average obtained in the mathematical creative thinking ability of students before being given treatment and after being given treatment also increased. Before being given treatment, the average of the students' mathematical creative thinking score was 72.44 and after being given treatment, the average score increased to 85.66.

Proportion tests were carried out to determine the completeness above KKM reaching 75% after the application of the STEM integrated PBL learning model. The data of the proportion test results are presented in the following table 3.

Table 3. Binomial Proportion Test Results

	Category	N	Test. Prop	Exact Sig. (2-tailed)
Posttest	<= 75	4	.50	0.001
	>75	32		
Total		36		

To find out the results of the test the proportion of one sample can be seen in the value of Exact Sig. (1-tailled). If Exact Sig.(1-tailled) > 0.05 then H_0 is accepted, and if Exact Sig.(1-tailled) < 0.05 then $H_0$is rejected. Table 1.1 shows Exact Sig. (1-tailled) 0.01 < 0.05 then $H_0$is rejected, so the result is that the proportion of students who get scores above the KKM is more than 75%.

The proportion test of one sample was carried out to determine the classical completion of students reaching 75%. Obtained exact Sig.(1-tailled) 0.01< 0.05 then H_0 rejected so the result was obtained that the proposed student who scored above KKM was more than 75%, so that the student was completed classically.

The N-Gain test was conducted to determine the improvement of students' mathematical creative thinking ability. The results of the calculation of N-Gain on the pretest and posttest of mathematical creative thinking ability are presented in table 4 below.

Table 4. N-Gain Test Results

Average grades		N-Gain	Criterion
Pretest	Posttest		
72.44	85.66	0,51	Medium

The results of the N-Gain test of each indicator of mathematical creative thinking ability, namely the fluency indicator, got a result of 0.38 in the medium category; the flexibility indicator got a result of 0.46 in the medium category; the elaboration indicator, namely getting a result of 0.48 in the medium category; the originality indicator got a result of 0.64 in the medium category. From the n-gain test, it was obtained that the average student's mathematical creative thinking ability for all indicators increased by 0.51 with a medium category obtained from the results of pretest and posttest scores. The following is a diagram of the student's N-Gain pretest and posttest results.

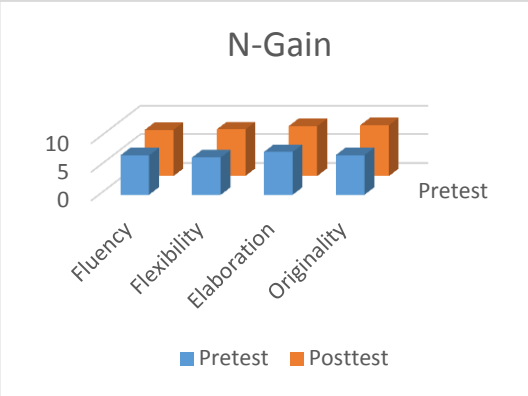

Figure 4. Student Results N-Gain

The results of the N-Gain test, each indicator of mathematical creative thinking ability, namely the smoothness indicator, got a result of 0.51 in the medium category.

The results of the t-test, proportion test and N-Gain showed an increase in mathematical creative thinking after being given a STEM-integrated PBL learning model. The STEM integrated PBL model is presented through teaching materials on SPLDV material which contains activities, examples of questions and problems that students can solve in a creative way.

PBL fosters students' creativity in solving mathematical problems (Maulidia et al., 2019). The integration of STEM in problem-based learning is able to guide students to solve problems given in groups, thereby encouraging students to work together who are responsible for their work independently and can manage discussion patterns that are suitable for the circumstances of their respective groups (Triwahyuningtyas et al., 2020).

The use of teaching materials can be one way to implement STEM-integrated PBL. Teaching materials in mathematics learning are a set of school mathematics materials that are arranged mathematically both written and unwritten in such a way as to create an atmosphere for students to learn mathematics (Gazali, 2016).

Students can not only focus on solving mathematical problems, but also have knowledge from other sciences to solve problems contained in STEM, thus providing students with creative thinking skills so that they can polish them optimally.

CONCLUSION

Based on the results of quantitative research, the average student pretest score was 72.44 and the average student posttest score was 85.66. The paired sample t-test showed that there were differences in students' grades before using STEM-integrated PBL learning. The proportion test of one sample showed that students who scored above KKM achieved classical completion. Improvement of each indicator of mathematical creative thinking ability, fluency indicator gets a result of 0.38 in the medium category; the flexibility indicator gets a result of 0.46 in the medium category; the elaboration indicator is to get a result of 0.48 in the medium category; the originality indicator gets a result of 0.6 4 on the medium category. From the N-G ain test it was obtained that the average student's mathematical creative thinking ability for all indicators increased by 0.51 with a moderate category obtained from the results of pretest and posttest scores.

Students' mathematical creative thinking ability is improved through STEM-integrated PBL learning. The application of STEM-integrated PBL learning can be integrated into media or learning resource materials accompanied by activities and problems in accordance with the ability to think creatively. The media and materials presented can use

interactive media and materials so as to attract students. Integrating STEM learning can be done with hands-on practical activities in a learning environment.

REFERENCES

Craig, T. T., & Marshall, J. (2019). Effect of project-based learning on high school students' state-mandated, standardized math and science exam performance. *Journal of Research in Science Teaching*, *56*(10), 1461–1488. https://doi.org/10.1002/tea.21582

Erdoğan, V. (2019). Integrating 4C Skills of 21st Century into 4 Language Skills in EFL Classes. *International Journal of Education and Research*, *7*(11), 113–124. www.ijern.com

Erlinawati, C. E., Bektiarso, S., & maryani. (2019). Model Pembelajaran Project Based Learning Berbasis Stem Pada Pembelajaran Fisika. *Seminar Nasional Pendidikan Fisika*, *4*(1), 1–4.

Gazali, R. Y. (2016). Pengembangan bahan ajar matematika untuk siswa SMP berdasarkan teori belajar ausubel. *PYTHAGORAS: Jurnal Pendidikan Matematika*, *11*(2), 182. https://doi.org/10.21831/pg.v11i2.10644

Jusuf, R., Sopandi, W., Wulan, A. R., & Sa'ud, U. S. (2019). Strengthening teacher competency through ICARE approach to improve literacy assessment of science creative thinking. *International Journal of Learning, Teaching and Educational Research*, *18*(7), 70–83. https://doi.org/10.26803/ijlter.18.7.5

Kotseva, I. (2019). Engineering Design-Based Learning in Integrative STEM Education. *Dl.Uctm.Edu*, *1*. https://dl.uctm.edu/see/node/jsee2019-1/9_SEE_19-11_p_62-67.pdf

Laforce, M., Noble, E., & Blackwell, C. (2017). Problem-based learning (PBL) and student interest in STEM careers: The roles of motivation and ability beliefs. *Education Sciences*, *7*(4). https://doi.org/10.3390/educsci7040092

Levenson, E., Swisa, R., & Tabach, M. (2018). Evaluating the potential of tasks to occasion mathematical creativity: definitions and measurements. *Research in Mathematics Education*, *20*(3), 273–294. https://doi.org/10.1080/14794802.2018.1450777

Maskur, R., Sumarno, Rahmawati, Y., Pradana, K., Syazali, M., Septian, A., & Palupi, E. K. (2020). The effectiveness of problem based learning and aptitude treatment interaction in improving mathematical creative thinking skills on curriculum 2013. *European Journal of Educational Research*, *9*(1), 375–383. https://doi.org/10.12973/eu-jer.9.1.375

Maulidia, F., Johar, R., & Andariah, A. (2019). a Case Study of Students' Creativity in Solving Mathematical Problems Through Problem Based Learning. *Infinity Journal*, *8*(1), 1. https://doi.org/10.22460/infinity

.v8i1.p1-10

Monica, Y., Rinaldi, A., & Rahmawati, N. D. (2021). *ANALISIS KEMAMPUAN BERPIKIR KREATIF MATEMATIS : DAMPAK MODEL OPEN ENDED DAN ADVERSITY QUOTIENT (AQ) Universitas Islam Negeri Raden Intan Lampung , Lampung , Indonesia Universitas Hasyim Asy ' ari , Jombang , Indonesia Institut Agama Islam Negeri Curup ,*. *10*(2), 550–562.

Saironi, M., & Sukestiyarno, Y. (2017). Kemampuan Berpikir Kreatif Matematis Siswa dan Pembentukan Karakter Rasa Ingin Tahu Siswa pada Pembelajaran Open Ended Berbasis Etnomatematika. *Unnes Journal of Mathematics Educatio Research*, *6*(1), 76–88. http://journal.unnes.ac.id/sju/index.php/ujmer

Sari, A. R., & Hardini, A. T. A. (2020). Meta Analisis Pengaruh Model Pembelajaran Problem Based Learning Terhadap Hasil Belajar Matematika. *Jurnal Ilmiah Pendidikan Profesi Guru*, *3*(1), 5.

Soumitra, D., Bruno, L., Rivera León, L., & Wunsch-Vincent, S. (2021). Global Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis. In *World Intellectual Property Organization* (Issue 14th Edition). https://www.bloomberg.com/topics/global-innovation-index%0Ahttp://www.wipo.int/publications/ru/series/index.jsp?id=129

Subakti, D. P., Marzal, J., & Hsb, M. H. E. (2021). Pengembangan E-LKPD Berkarakteristik Budaya Jambi Menggunakan Model Discovery Learning Berbasis STEM Untuk Meningkatkan Kemampuan Berpikir Kreatif Matematis. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *05*(02), 1249–1264. https://www.j-cup.org/index.php/cendekia/article/view/629/339

Sugiyono. (2010). *Metode Penelitian Pendidikan* (10th ed.). IKAPI.

Triwahyuningtyas, D., Ningtyas, A. S., & Rahayu, S. (2020). The problem-based learning e-module of planes using Kvisoft Flipbook Maker for elementary school students. *Jurnal Prima Edukasia*, *8*(2), 199–208. https://doi.org/10.21831/jpe.v8i2.34446

Wijaya, T. T., Zhou, Y., Ware, A., & Hermita, N. (2021). Improving the Creative Thinking Skills of the Next Generation of Mathematics Teachers Using Dynamic Mathematics Software. *International Journal of Emerging Technologies in Learning*, *16*(13), 212–226. https://doi.org/10.3991/ijet.v16i13.21535

Zakiah, N. E., Fatimah, A. T., & Sunaryo, Y. (2020). Implementasi Project-Based Learning Untuk Mengeksplorasi Kreativitas Dan Kemampuan Berpikir Kreatif Matematis Mahasiswa. *Teorema: Teori Dan Riset Matematika*, *5*(2), 286. https://doi.org/10.25157/teorema.v5i2.4194