



TECHNIUM
SOCIAL SCIENCES JOURNAL

www.techniumscience.com



Vol. 72/2025
A New Decade for Social Changes

PLUS
COMMUNICATION P



International
Communication & PR

The Effect of the GeoGebra-Assisted Problem-Based Learning Model on Mathematical Creative Thinking Ability

Nurhayati Abbas, St. Nur Qamariah Katili, Tedy Machmud

Magister Pendidikan Matematika, Fakultas Pascasarjana, Universitas Negeri
Gorontalo, Indonesia

pps@ung.ac.id, nurqamariahkatili@gmail.com, tedy_m@ung.ac.id

Abstract. This research aims to examine the effectiveness of the GeoGebra-assisted Problem-Based Learning model on mathematical creative thinking abilities, considering initial mathematics ability. The study employed a quasi-experimental design using a 2x2 treatment level with two-way analysis and the Tukey test. The research was conducted in Class VIII of SMP Negeri 1 Kabila during the even semester of the 2023-2024 academic year. Data were collected through a descriptive mathematical creative thinking ability test and a multiple-choice initial mathematics ability test. The analysis of the mathematical creative thinking ability data was based on categorizing the initial mathematics ability test scores, which served as a moderator variable, distinguishing between high and low initial mathematics abilities. Data analysis utilized two-way analysis of variance to test the research hypotheses. The results of this study indicate that: (1) Students' mathematical creative thinking abilities taught using the GeoGebra-assisted Problem-Based Learning model are higher compared to those taught with conventional learning models; (2) There is an interaction effect between the learning model and initial mathematics ability on students' mathematical creative thinking abilities; (3) Students with high initial mathematics ability taught using the GeoGebra-assisted Problem-Based Learning model demonstrate higher mathematical creative thinking abilities than those taught with conventional learning models; (4) Students with low initial mathematics abilities taught using the GeoGebra-assisted Problem-Based Learning model exhibit lower mathematical creative thinking abilities than those taught using conventional learning models.

Keywords. GeoGebra-assisted Problem-Based Learning Model, Mathematical Creative Thinking Ability, Quasi-Experimental Design

Introduction

Mathematics learning is often accompanied by various difficulties, particularly in problem-solving, which can be both complex and unfamiliar to students. Addressing such problems necessitates the development of robust creative thinking skills. The cultivation of these competencies is paramount for students to navigate and solve mathematical problems effectively. The degree to which a student is able to think creatively directly correlates with their effectiveness in problem-solving.

Mathematical thinking encompasses structured and logical reasoning, even in the absence of empirical objects or when such objects cannot be illustrated. The cultivation of

mathematical thinking stands as a fundamental facet of the mathematics learning process. The ability to think creatively in mathematics encompasses problem-solving skills, the capacity to process thoughts structurally, to express ideas that differ from conventional deductive logic, and to prioritize general concepts that unify essential aspects of mathematics. When students possess a high level of mathematical creative thinking, they can generate a wide range of alternative solutions to a single problem. Beyond the sheer quantity of these responses, the quality of the responses is also of paramount importance. Indeed, the act of creative thinking requires students to understand, master, and solve a variety of problems. Consequently, when confronted with a problem, students are expected to propose innovative and creative ideas or solutions during the analysis and problem-solving processes.

According to Guilford, the following four indicators are associated with creative thinking: fluency (the ability to generate numerous ideas, answers, solutions, or questions), flexibility (the ability to produce varied ideas based on available information), originality (the ability to present new and unique ideas that differ from existing solutions), and elaboration (the ability to expand and refine ideas in detail to make them more compelling). A study of eighth-grade students at SMP Negeri 1 Kabila reveals that they have yet to demonstrate the capacity for creative thinking in the domain of mathematical problem-solving. This assertion is substantiated by observational data and examination results, which indicate that students frequently exhibit a deficiency in confidence when confronted with mathematical problems. Their responses are often concise, and on average, they are unable to provide complete solutions to the problems.

While the teaching process was found to be conducted adequately, encouraging students to relate the material to real-life contexts and providing exercises for practice, the findings indicate a deficiency in students' mathematical creative thinking skills. However, it is unfortunate that teachers have not yet trained students to develop their mathematical creative thinking skills. Consequently, students were unaccustomed to encountering problems that required creative thinking, with some students appearing passive during lessons and while completing tasks. Consequently, when teachers posed problems, students lacked confidence in expressing their thoughts and tended to remain silent, waiting for the teacher's help.

To address this gap, educators must adopt innovative instructional designs, such as the Problem-Based Learning (PBL) model, to facilitate the development of mathematical creative thinking skills in students. This learning model not only underscores constructive learning activities but also holds the potential to enhance students' creativity significantly. Under this paradigm, the traditional teacher-centered model evolves into a facilitator-driven and student-centered model, wherein teachers transition from a passive role to that of a facilitator and motivator. At the same time, students are empowered to construct their knowledge through active engagement.

In addition to the adoption of learning models, the integration of appropriate and varied instructional media has been demonstrated to reduce passive attitudes among students and enhance the learning process's engagement. The integration of technology into contemporary education is imperative. One such technological tool suitable for mathematics instruction is GeoGebra. GeoGebra is a dynamic, free, and multi-platform mathematics application that combines geometry, algebra, spreadsheets, graphing, statistics, and calculus in a single, user-friendly platform suitable for all education levels. Its interactive features and user-friendly interface can make the learning process more exciting and engaging for students.

The present study, titled **"The Effect of the GeoGebra-Assisted Problem-Based Learning (PBL) Model on Mathematical Creative Thinking Ability,"** aims to investigate

the impact of the PBL model, augmented by the GeoGebra application, on enhancing mathematical creative thinking abilities among students with varying initial mathematical aptitudes. The objective of this study is not just to analyze the effectiveness of using the PBL model assisted by GeoGebra, but to significantly contribute to the understanding and enhancement of students' creative mathematical thinking abilities in the field of mathematics education.

Methods

This study employs a quasi-experimental research design, utilizing a 2x2 treatment by level design. The research design is delineated in Table 1. The study's variables include the learning model (A) as the independent variable, mathematical creative thinking ability (Y) as the dependent variable, and initial mathematical ability (B) as the moderating variable.

Tabel 1. Research Design 2x2 Treatment by Level

| | | Learning Model (A) | |
|----------------------------------|------------------------|--|---|
| | | Problem-Based Learning Model (A ₁) | Direct Learning Model (A ₂) |
| Initial Mathematical Ability (B) | High (B ₁) | A ₁ B ₁ | A ₂ B ₁ |
| | Low (B ₂) | A ₁ B ₂ | A ₂ B ₂ |

Description:

A₁ B₁ = Group of students with high initial mathematical ability who were taught using the Problem-Based Learning model

A₂ B₁ = Group of students with high initial mathematical ability who were taught using the direct learning model

A₁ B₂ = Group of students with low initial mathematical ability who were taught using the Problem-Based Learning model

A₂ B₂ = Group of students with low initial mathematical ability who were taught using the direct learning model

The initial mathematics ability test was developed in the form of multiple-choice questions based on Bloom's Taxonomy domain. Conversely, the assessment of students' mathematical creative thinking ability was formulated as an essay question. The collected research data were then subjected to two types of analysis: descriptive analysis and inferential analysis. Hypothesis testing in this study was conducted using two-way analysis of variance (ANOVA 2 x 2) with the F-test.

Research results and discussion

Research Results

The data presented in Table 1 describe the mathematical creative thinking abilities across eight groups. The eight groups in question are as follows: students who have been taught using the Problem-Based Learning model (A₁); students who have been taught using the Direct Learning model (A₂); students with high initial mathematical ability (B₁); students with low initial mathematical ability (B₂); students with high initial mathematical ability who have been taught using the Problem-Based Learning model (A₁B₁); students with low initial mathematical ability who have been taught using the Problem-Based Learning model (A₁B₂); students with high initial mathematical ability taught using the Direct Instruction model (A₂B₁); and students

with low initial mathematical ability who have been taught using the Direct Instruction model (A₂B₂).

Table 2. Descriptive Data of Mathematical Creative Thinking Ability of Eighth-Grade Students at SMP Negeri 1 Kabila

| Category | A ₁ | A ₂ | B ₁ | B ₂ | A ₁ B ₁ | A ₂ B ₁ | A ₁ B ₂ | A ₂ B ₂ |
|---------------------------|----------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| N | 40 | 40 | 40 | 40 | 20 | 20 | 20 | 20 |
| Mean | 9.45 | 8.55 | 9.9 | 8.1 | 10.9 | 8.9 | 8 | 8.2 |
| Median | 10 | 9 | 10 | 8 | 11 | 9 | 8 | 8 |
| Mode | 10 | 9 | 11 | 8 | 11 | 9 | 8 | 8 |
| Standard Deviation | 1.9605 | 1.7824 | 1.7512 | 1.6455 | 1.0712 | 1.7442 | 1.5218 | 1.7947 |
| Maximum Score | 13 | 12 | 13 | 11 | 13 | 12 | 10 | 11 |
| Minimum Score | 4 | 4 | 5 | 4 | 9 | 5 | 4 | 4 |

1. Data on Students' Mathematical Creative Thinking Ability Taught Using the Problem-Based Learning Model

The results of the mathematical creative thinking ability test administered to 40 students indicated that the maximum score attained was 13, while the minimum score was 4. The mean score was 9.45, the median was 10, the mode was 8 and 10, and the standard deviation (SD) was 1.9605. A subsequent comparison of the mode with the mean and median revealed that the mode was higher than both the mean and the median. A total of 19 students, constituting 47.5% of the sample, scored below the mean score class. Meanwhile, eight students, accounting for 20% of the sample, fell within the mean score class. Finally, 21 students, representing 32.5% of the sample, scored above the mean score class.

2. Data on Students' Mathematical Creative Thinking Ability Taught Using the Direct Learning Model

The results of the mathematical creative thinking ability test, administered to a sample of 40 students, revealed a maximum score of 12, while the minimum score was 4. The mean score was 8.55, the median was 9, the mode was 9, and the standard deviation (SD) was 1.7824. A notable finding was that the mode coincided with both the mean and the median. The distribution of scores revealed that 18 students, constituting 45% of the sample, obtained a score below the mean class level. In addition, 11 students, representing 27.5% of the sample, fell within the mean class level. Notably, 11 students, accounting for 27.5% of the sample, attained scores above the mean class level.

3. Data on Students' Mathematical Creative Thinking Ability with High Initial Mathematical Ability

The results of the mathematical creative thinking ability test, administered to 40 students, revealed a range of scores from 5 to 13. The mean score was 9.9, the median score was 10, and the most frequently occurring score was 11. The standard deviation (SD) was 1.7512. A comparative analysis revealed that the mode exceeded both the mean and the median. A total of 15 students, representing 37.5% of the sample, scored below the average category. Meanwhile, eight students, constituting 20% of the sample, fell within the average category. Finally, 17 students, accounting for 42.5% of the sample, scored above the average category.

4. Data on Students' Mathematical Creative Thinking Ability with Low Initial Mathematical Ability

The results of the mathematical creative thinking ability test, administered to a sample of 40 students, revealed a range of scores from 4 to 11. The arithmetic mean of these scores was 8.1, the median was 8, and the most frequently observed score was also 8. The standard deviation of the scores was 1.6455. A noteworthy observation is that the mode coincided with both the mean and the median, underscoring the symmetry between these statistical metrics. A total of 24 students, representing 60% of the sample, scored below the average category. Eight students, or 22.5%, were in the average category, and seven students, or 17.5%, scored above the average category.

5. Data on Students' Mathematical Creative Thinking Ability with High Initial Mathematical Ability Taught Using the Problem-Based Learning Model

The results of the mathematical creative thinking ability test, administered to 20 students, revealed a range of scores from 9 to 13. The mean score was 10.9, the median was 11, and the most frequently observed score was also 11. The standard deviation (SD) was 1.0712. The distribution of scores revealed that seven students, constituting 35% of the sample, obtained scores below the average category. An additional seven students, representing 35% of the sample, were positioned in the average score category. Notably, six students, accounting for 30% of the sample, attained scores that fell above the average category.

6. Data on Students' Mathematical Creative Thinking Ability with High Initial Mathematical Ability Taught Using the Direct Learning Model

The results of the mathematical creative thinking ability test, administered to 20 students, revealed a range of scores from 5 to 12. The arithmetic mean of these scores was 8.9, the median was 9, and the most frequently occurring score was also 9. The standard deviation of the scores was 1.7442. The distribution of scores revealed that seven students, constituting 35% of the sample, obtained scores below the average category. In contrast, six students, representing 30% of the sample, were positioned in the average score category. Notably, seven students, accounting for 35% of the sample, attained scores that fell above the average category.

7. Data on Students' Mathematical Creative Thinking Ability with Low Initial Mathematical Ability Taught Using the Problem-Based Learning Model

The results of the mathematical creative thinking ability test, administered to 20 students, revealed a range of scores from 4 to 10. The arithmetic mean, median, and mode of this distribution were 8, 8, and 8, respectively. The standard deviation was calculated to be 1.5218. A total of 5 students, or 25%, scored below the average category; 8 students, or 40%, were in the average category; and 7 students, or 35%, scored above the average category.

8. Data on Students' Mathematical Creative Thinking Ability with Low Initial Mathematical Ability Taught Using the Direct Learning Model

The results of the mathematical creative thinking ability test, administered to 20 students, revealed a range of scores from 4 to 11. The arithmetic mean of these scores was 8.2, the median was 8, and the most frequently occurring score was also 8. The standard deviation of the scores was 1.7947. The analysis revealed that 11 students, representing 55% of the sample, obtained scores below the average category. In contrast, 5 students, constituting 25% of the sample, were positioned in the average score category. Notably, 4 students, accounting for 20% of the sample, attained scores above the average category.

Discussion

The direct instruction model is predicated on the sequential delivery of instructional material from teacher to students, with the objective of ensuring that students fully master the subject matter being taught. In this approach, students receive pre-prepared learning materials the teacher presents primarily through various lecture forms. A distinguishing feature of this

pedagogical model is the pronounced role of the instructor in the learning process. The instructor employs a structured approach, presenting the material and subsequently providing example problems and their corresponding solutions. This finding suggests that students are not provided with sufficient opportunities to develop their knowledge independently, but rather, they gradually build understanding through exercises provided by the teacher. The findings of this study indicate that the Problem-Based Learning (PBL) model demonstrates greater efficacy in comparison to the direct instruction model and appears to be reasonably appropriate for implementation in school settings.

Following the first hypothesis, the findings of this study demonstrate that both the PBL model and the direct instruction model significantly impact students' mathematical creative thinking ability. The two-way ANOVA (2x2) test findings indicated a substantial discrepancy in the impact of PBL and direct instruction on students' mathematical creative thinking skills. The mean score of students taught using the PBL model was higher than that of students taught using direct instruction. This finding indicates that the PBL model performs better than the direct instruction model. In the PBL approach, learning materials are systematically connected to students' real-life experiences, helping sustain student engagement during the learning process. Furthermore, in PBL, students are grouped and encouraged to exchange ideas, promoting active classroom discussions. In this model, the teacher functions as a facilitator, monitoring and guiding students as they navigate challenging concepts or areas of confusion.

The second hypothesis test demonstrates a significant interaction effect between the learning model and students' initial mathematical ability on their mathematical creative thinking skills. This interaction suggests that the learning model and the students' initial mathematical ability positively synergize to produce optimal outcomes. The findings of this study demonstrate that both the PBL and direct instruction models significantly impact students' mathematical creative thinking abilities, regardless of whether students have high or low initial mathematical ability. This phenomenon is substantiated by the mean scores attained by students in the domain of mathematical creative thinking. Pupils who demonstrated superior initial mathematical aptitude and were instructed via the PBL (Problem-Based Learning) model attained mean scores that surpassed those of their counterparts who received direct instruction. The average scores between the two instructional models were relatively similar for students with low initial mathematical ability. These findings suggest that the PBL model benefits students with high and low initial mathematical abilities.

The findings of the third hypothesis test demonstrate a substantial discrepancy in mathematical creative thinking aptitude between students with high initial mathematical aptitude who were instructed using the PBL model and those who were instructed using the direct instruction model. This discrepancy is evident in the mean scores, where students with high initial ability who were taught using PBL scored higher than those taught using direct instruction ($10.9 > 8.9$). These findings suggest that the PBL model is particularly well-suited for students with high initial mathematical ability. The PBL model's strength lies in its emphasis on student-centred learning instead of the teacher-centred nature of direct instruction. Active student participation in the learning process, especially among students with high initial ability, enriches their experiences and enhances their skills, particularly in fostering mathematical creativity. The PBL model affords students greater opportunities to articulate their mathematical ideas. In contrast, direct instruction frequently restricts students to a passive role, with knowledge transmitted solely from teacher to student, thereby impeding the cultivation of creativity.

The fourth hypothesis test reveals a discrepancy in mathematical creative thinking ability between students with low initial mathematical ability who were taught using the PBL model and those taught using the direct instruction model. With respect to mean values, the discrepancy is not significant. In the present study, students who were initially assigned to the low-ability group and were instructed via the Problem-Based Learning (PBL) method demonstrated an average score of 8.0. In contrast, students who were initially assigned to the low-ability group and were instructed via the Direct Instruction (DI) method exhibited an average score of 8.2. However, the findings indicate that students with low initial ability who were taught using the PBL model exhibited a lower SD than those taught using direct instruction ($1.5218 < 1.7947$). These findings imply that the direct instruction model may be more appropriate for students with limited prior mathematical experience. The PBL model prioritizes student activity and skill development, encompassing comprehension, interpretation, interaction, and creativity, both oral and written. It is hypothesized that students with low initial mathematical ability possess certain limitations and weaknesses in these areas. This may result in more challenges for these students when engaging effectively with the PBL approach.

A comprehensive evaluation of the PBL model reveals its potential to cater to students with varying degrees of initial mathematical aptitude. However, these students may require adjustment to align their capabilities with the demands of the PBL learning process. Teachers must support this adjustment by fostering learning environments that develop student activity and ability. Additionally, the instructor plays a pivotal role in the PBL model, particularly for students with limited mathematical aptitude. As facilitators, teachers are responsible for overseeing the learning process and providing guidance and direction throughout instruction.

Conclusion

This research aims to examine the effectiveness of the GeoGebra-assisted Problem-Based Learning model on mathematical creative thinking abilities, considering initial mathematics ability. The findings of the study indicate a substantial discrepancy in the mathematical creative thinking abilities of students who have been taught using the Problem-Based Learning (PBL) model as opposed to those taught using the direct instruction model. The results of the F-test demonstrate that the calculated F-value exceeds the critical F-table value ($6.66 > 3.98$) at a significance level of $\alpha = 0.05$. This discrepancy is further evidenced by the mean scores attained by students, with the PBL model yielding an average of 9.45 and the direct instruction model yielding an average of 8.55. When considered in the context of students' initial mathematical aptitudes, the data reveal an interaction effect between the learning model and students' initial abilities on their mathematical creative thinking skills. Students who initially demonstrated high mathematical ability exhibited a substantial enhancement in creative mathematical thinking when instructed using the problem-based learning (PBL) model instead of the direct instruction model. This discrepancy is further substantiated by the higher average scores attained by students in the PBL group. Conversely, students with low initial mathematical ability demonstrated no significant difference in mathematical creative thinking skills between the two instructional models. The mean score of students taught using the PBL model was 8.0, while that of those taught using direct instruction was 8.2. In summary, the implementation of the PBL model has been shown to yield positive outcomes in enhancing students' mathematical creative thinking abilities, particularly among students with high initial mathematical ability. For students who demonstrate an initial mathematical aptitude that is below average, modifications may be required before they engage with PBL-based instruction to ensure its efficacy.

References

- [1] Arikunto, S., "Prosedur Penelitian", Jakarta : Rjneka Cipta, 2010
- [2] Bahar, A. K & Maker, C. J., "Exploring the Relationship Between Mathematical Creativity and Mathematical Achievement, AsiaPasific Journal of Gifted and Talented Education", Volume 3, Issue 1, 33-48, 2011.
- [3] Delisle, R. 1997. How to Use Problem-Based Learning in Classroom. Alexandria, Virginia: ASCD.
- [4] Divjak, B., Ostroski, M. (2009). Learning outcomes in mathematics: Case study of their implementation and evaluation by using e-learning. Zagreb: Article in ResearchGate.
- [5] Duch, B. J., Groh, S. E. & Allen, D. E. 2001. The Power of Problem-Based Learning: A Practical HOW to for Teaching Undergraduate Courses in Any Discipline. Sterling, VA: Stylus.
- [6] Hanafi. 2010. Pengaruh Model Problem Based Learning terhadap Hasil Belajar Matematika ditinjau dari Kemampuan Awal Peserta Didik, tidak diterbitkan. Program Pascasarjana Universitas Negeri Gorontalo
- [7] Herman, T. 2007. Pembelajaran Berbasis Masalah untuk Meningkatkan Kemampuan Berpikir Matematis Tingkat Tinggi Siswa Sekolah Menengah Pertama. Jurnal Educationist, 1 , 47-56.
- [8] Lalu Imam Maulana, 'Pengaruh Penggunaan Media *GeoGebra* Terhadap Hasil Belajar Matematika Siswa Dalam Materi Sistem Koordinat Kartesius Pada Siswa Kelas VIII Di MTsN 3 Mataram Tahun Ajaran 2019/2020' (Skripsi UIN Mataram Makassar, 2020).
- [9] MacMath, S., Wallace, J., & Xiaohong, C. 2009. Problem-Based Learning in Mathematics, A Tool for Developing Students Conceptual Knowledge. The Literacy and Numeracy Secretariat. Research Monograph (online). (http://edu.gov.on.ca/eng/literacynumeracy/inspire/research/wh_whatWorks.html, diakses 30 November 2020).
- [10] Padrnavathy, R. D. & Mareesh, K. 2013. Effectiveness of problem Based Learning in Mathematics. Intemational Multidiciplinary e-Journal, 2, 45-51.
- [11] Purnomo Joko, "Kebermanfaatan Penggunaan *GeoGebra* Dalam Pembelajaran Matematika", *Journal Of Mathematics and Education*, 8 (2021),
- [12] Pomatato, S. 2005. Pengaruh Penerapan Model Tremnger pada Pembelajaran Matematika dalam Mengembangkan Kemampuan Kreatif Matematik dan Kemampuan Pemecahan Masalah Matematika Siswa Kelas 2 Sekolah Menengah Pertama. Disertasi Tidak Diterbitkan. Bandung : Program Pascasarjana UPI Bandung.
- [13] Rahmat Adam, "Pengaruh Penggunaan Media Pembelajaran *GeoGebra* Terhadap Kemampuan Representasi Matematik Siswa" (Skripsi UIN Syarif Hidayatullah Jakarta, 2015).
- [14] Setiawan, dkk. 2010. Penerapan Model Pengajaran Langsung (Direct Instruction) untuk Meningkatkan Pemahaman Belajar Siswa dalam Pembelajaran Rekayasa Perangkat Lunak (RPL). Jurnal Pendidikan Teknologi Informasi dan Komunikasi (PTIK) Vol. 3 No.1 Penyingkiran
- [15] Stenberg, R. J. 2003. Creative Thinking in The Classroom. Scandinavian Journal of Education Research, Vol 47, No. 3, 325-338.
- [16] Sudjana, N. (2005). Metoda Statistik. Bandung : PT. Tarsito.

- [17] Sugiono. 2014. *Metode Penelitian Pendidikan Kuantitatif IT dan R & D*. Bandung: Alfabeta.
- [18] Syandy Agung, “Pemanfaatan Aplikasi *GeoGebra* Dalam Pembelajaran Matematika SMP”, *Journal Prosiding Seminar Nasional*, 3 (2019), 314.