p-ISSN: 2086-4280
e-ISSN: 2527-8827

Enhancing Creative Mathematical Thinking Skills using Creative Problem Solving Assisted by GeoGebra

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Article received: 17-08-2025, revised: 07-09-2025, published: 30-10-2025

Abstrak

Kemampuan berpikir kreatif matematis peserta didik di Indonesia masih tergolong rendah. Penyebab hal tersebut diantaranya penggunaan model pembelajaran dan media pembelajaran yang kurang mendorong tumbuhnya kemampuan berpikir kreatif matematis peserta didik, sehingga dibutuhkan pemilihan model dan media pembelajaran inovatif yang dapat menumbuhkan kemampuan berpikir kreatif matematis. Salah satunya adalah penggunaan model pembelajaran Creative Problem Solving (CPS) dan media pembelajaran software GeoGebra. Tujuan dari penelitian ini adalah untuk mengetahui bagaimana peningkatan kemampuan berpikir kreatif matematis peserta didik yang pembelajarannya menggunakan model pembelajaran CPS dengan media GeoGebra dan model pembelajaran CPS dengan media PowerPoint. Selain itu, pada penelitian ini dikaji bagaimana perbedaan peningkatan kemampuan berpikir kreatif matematis kedua kelompok tersebut. Pada penggunaan media software GeoGebra diobservasi bagaimana respon peserta didik setelah penggunaan GeoGebra selama kegiatan pembelajaran. Hasil dari uji gain, uji-t dan uji mann-whitney dapat disimpulan penggunaan model CPS berbantuan GeoGebra dapat meningkatkan kemampuan berpikir kreatif. Sebagian besar respon peserta didik setelah penggunaan GeoGebra selama kegiatan pembelajaran adalah sangat baik.

***Kata Kunci**: Berpikir Kreatif; GeoGebra; Creative Problem-Solving Model.*

Abstract

Students' mathematical creative thinking skills in Indonesia are still considered low. This is partly caused by the use of learning models and media that do not sufficiently encourage the growth of these skills; therefore, it is necessary to select innovative learning models and media that can foster mathematical creative thinking. One such approach is the use of the Creative Problem Solving (CPS) model and GeoGebra software. The purpose of this research is to determine the improvement of students' mathematical creative thinking skills through the implementation of the Creative Problem Solving (CPS) model assisted by GeoGebra compared to the CPS model assisted by PowerPoint. Furthermore, this study examines the difference in the improvement of creative thinking skills between the two groups. Regarding the use of GeoGebra, students' responses were observed after its implementation in learning activities. Based on the results of the N-gain test, t-test, and Mann-Whitney test, it can be concluded that the use of the CPS model assisted by GeoGebra can improve creative thinking skills. Moreover, the majority of students' responses toward the use of GeoGebra during learning activities were very good.

Keywords: Creative Thinking; GeoGebra; Creative Problem Solving Model.

I. PENDAHULUAN

Education continuously evolves in alignment with advancements in science and technology (Qomariyah & Subekti, 2021). This dynamic requires knowledge to constantly adapt to the changing times (Muhamad et al., 2018). Within this context, mathematics plays a crucial role as a fundamental science that supports the mastery of technology (Atiyah & Nuraeni, 2022). Along with the ease of access to information in the digital era, students are required to have the proficiency to filter data to avoid disinformation. Therefore, developing critical, logical, and creative mindsets is a primary foundation for students to interact healthily within a technology-driven social life (Sari et al., 2022).According to Faturohman & Afriansyah (2020), creative thinking ability is classified as a higher-order thinking skill (HOT). Creative thinking is a high-level competence and can be considered a basic skill in mathematics learning (Ginting et al., 2019). In mathematics classes, students often encounter problems that require problem-solving skills. Therefore, it is important for students to have creative thinking abilities so they can solve the problems they face with creative solutions, as mathematics does not always have to be solved using the same method as before (Dalilan & Sofyan, 2022).

The low level of students' creative thinking skills remains a significant challenge in Indonesian education. Findings by Puspaningrum (2020) at SMP Negeri 1 Bukit Tinggi confirm that students' creative thinking abilities are still categorized as low. This issue is triggered by the stigma that mathematics is a difficult and tedious subject. Furthermore, the dominance of lecture-based methods or direct instruction in the classroom causes students to become passive and lose interest, as they primarily function as listeners without active engagement.

The obstacles in fostering student creativity are rooted in the orientation of education in Indonesia, which still emphasizes final results, such as memorization skills and the search for a single correct answer (Supriati, 2022). This pattern conditions students to rely on uniform problem-solving methods dictated by the teacher, thereby hindering their creative thinking potential. To address this, the development of creativity must be integrated into all aspects of learning, which heavily depends on the effectiveness of the teacher's role, the selection of methods, and the use of learning media (Sumartini, 2022). Improving this suboptimal instructional process is key to achieving the desired educational outcomes.

One of the computer programs that can be utilized in education, particularly in mathematics, is GeoGebra. GeoGebra is a software tool that can support mathematics learning; it can even assist in the preparation of teaching materials and, more impressively, serve as a tool to help solve mathematical problems (Ginting et

al., 2018). Puspita et al. (2023) state that GeoGebra and Microsoft Math 4.0 are two examples of educational software that can be used because they make it easier for teachers to explain mathematical concepts and enhance students' creativity in solving mathematical problems. GeoGebra can serve as an alternative technology to be implemented in mathematics learning using the PjBL (Project-Based Learning) model to enhance students' creative thinking skills (Junita & Masrukan, 2025).

Lestari (2018) highlights that in mathematics education practices, students tend to be instructed only to memorize concepts or formulas without being introduced to the relevance of real-world problems. The complexity of mathematical structures is often a major barrier to comprehension; therefore, the concretization of concepts is essential to facilitate the assimilation of knowledge by students (Sundayana, 2018). Although conceptual understanding is a vital foundation, reality in the field indicates that students' limited ability to grasp concepts remains the greatest challenge (Hasanah et al., 2020). Ultimately, this deficit in understanding risks triggering systematic errors in mathematical problem-solving.

Sequences and series represent a mathematical topic characterized by a broad and contextual scope (Krisdarani et al., 2024). However, Silaban et al. (2022) revealed that students still face significant obstacles in solving problems within this topic due to difficulties in problem comprehension. As a solution, the implementation of GeoGebra software has proven effective in enhancing students' conceptual and procedural understanding (Sumartini & Maryati, 2021). The utilization of GeoGebra enables the visualization and modeling of abstract geometric concepts into more concrete forms, which in turn optimizes teachers' instructional strategies beyond the limitations of conventional methods (Awaji et al., 2025). Furthermore, this technology supports the development of strategic competence and problem-solving skills, which, according to Elgrably and Leikin (2021), serve as primary instruments in fostering mathematical creativity within the school environment.

In addition to the use of instructional media, the selection of an appropriate learning model must also be considered to ensure an effective learning process, particularly to enhance students' mathematical creative thinking skills. A suitable learning model for improving students' mathematical creative thinking is the Creative Problem Solving (CPS) model (Faturohman & Afriansyah, 2020). The Creative Problem Solving model emphasizes creativity as a fundamental ability that students use in solving problems (Ginting et al., 2019). Research conducted by Ginting et al. at SMP Negeri 17 Bekasi showed that the CPS model has an influence on students' creative thinking abilities.

The syntax or learning process in the CPS model consists of four stages:

1. Problem clarification,
2. Idea generation,
3. Evaluation and selection, and
4. Implementation (Shoimin, 2016; Yani & Widiyatmoko, 2023).

In the first stage, problem clarification, students are expected to imagine and understand the given problem or task. At this early stage, students must be able to mentally visualize the real context of the problem. Therefore, the use of GeoGebra software can be applied here, as it helps in visualizing mathematical problems in a concrete way. Implementing GeoGebra in this initial stage can stimulate and open students' thinking to become more creative, so that in the second stage—idea generation, where students express opinions or propose potential solutions—they are able to come up with creative and effective ideas.

Based on the background described above, this study aims to investigate the improvement of students' mathematical creative thinking skills in learning environments that apply the CPS model, use GeoGebra software as a learning aid, or combine both. Additionally, this study examines the differences in the improvement of mathematical creative thinking between the two groups. Furthermore, students' responses to the use of GeoGebra during the learning process will also be observed.

II. METODE

The research approach used is a quantitative approach, with the method applied being a quasi-experimental method. The research design employed is the non-equivalent group pretest-posttest design. The design of the study is illustrated as follows (Ruseffendi, 2010)

$$\begin{array}{c} O\ X_1\ O \\ \text{----------} \\ O\ X_2\ O \end{array}$$

Keterangan:
O : Administration of the pretest and posttest.
X_1 : Implementation of the Creative Problem Solving learning model assisted by GeoGebra.
X_2 : Implementation of the Creative Problem Solving learning model assisted by PowerPoint.
- : The subjects were not selected randomly

In this research design, two groups were selected at random, both of which were given a pre-test to determine the initial state of mathematical creative thinking skills in each group. Subsequently, both groups were given a post-test after receiving different treatments in experimental group 1 and experimental group 2.

This research was conducted at a public high school in Garut, with the study population comprising all tenth-grade students. The sampling technique employed was purposive sampling, selecting two experimental classes: class X-2 as experimental group 1 (41 students) and class X-3 as experimental group 2 (43 students). However, the final data analyzed

consisted of 29 students from experimental group 1 and 31 students from experimental group 2. This discrepancy occurred because not all students participated in the entire series of activities from the pre-test to the post-test.

Data collection techniques included a mathematical creative thinking ability test, student response questionnaires regarding the use of GeoGebra software, and documentation of activities. The mathematical creative thinking test consisted of five essay questions. Both the test items and the marking rubrics were developed based on the indicators of mathematical creative thinking: 1) Fluency, 2) Flexibility, 3) Originality, and 4) Elaboration. The results of the students' mathematical creative thinking ability tests were classified based on a scale of 100 as follows in Table 1.

Table 1.
Test Score Classification

Score Interval	Classification
0-19	Not Creative
20-39	Less Creative
40-59	Sufficiently Creative
60-79	Creative
80-100	Very Creative

III. RESULTS AND DISCUSSION

a. Research Results

1) Improvement of Mathematical Creative Thinking Ability

Experimental group 1 is a class that receives learning assisted by GeoGebra software and utilizes the CPS learning model. The number of students in the GeoGebra-CPS group is 29. Meanwhile, experimental group 2 is a class that utilizes only the CPS learning model. The number of students in the CPS group is 31. The following are the test results of mathematical creative thinking ability for the GeoGebra-CPS and CPS groups

a) Data on Mathematical Creative Thinking Ability Test Results

The following presents the pretest and posttest scoring results of mathematical creative thinking ability for the GeoGebra-CPS and CPS groups.

Table 2.
Results of Mathematical Creative Thinking Ability

		GeoGebra-CPS Group	CPS Group
Pretest	Ideal Score	75	75
	Highest Score	41	35
	Lowest Score	0	0
	$Mean\ (\bar{x})$	16.4828	14.000
Postest	Ideal Score	75	75
	Highest Score	72	57
	Lowest Score	33	28
	$Mean\ (\bar{x})$	50.1724	46.8372

Based on Table 2, it is evident that there was an increase in scores after the treatment was given to both groups. From the ideal score of 75, it can be seen that before the treatment, the average pretest score of the GeoGebra-CPS group was 16.48, and after the treatment, the average posttest score increased to 50.17. Similarly, in the CPS group, the average pretest score

was 14, and the posttest score increased to 46.83.

b) Data on the Improvement (N-Gain) of Mathematical Creative Thinking Ability

The following presents the results of the normalized gain test (N-Gain) for the mathematical creative thinking ability of the GeoGebra-CPS group and the CPS group.

Table 3.
Recapitulation of the Improvement in Mathematical Creative Thinking Ability

Group	N-Gain Score Classification	Number of Students	Percentage (%)
GeoGebra-CPS	Medium	25	86
	High	4	14
CPS	Low	1	3
	Medium	30	97

The improvement in mathematical creative thinking ability in both groups appears to be positive. This is reflected in Table 3, where in the GeoGebra-CPS group, 86% of students showed a medium level of improvement and 14% showed a high level of improvement. In the CPS group, 97% of students showed a medium level of improvement, while 3% showed a low level of improvement.

2) Comparison of the Improvement in Mathematical Creative Thinking Ability

The following presents the improvement data (N-Gain) from both groups:

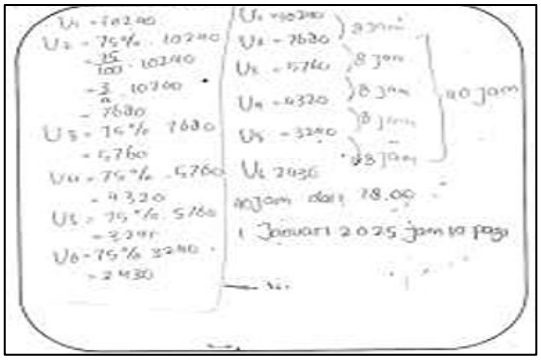

Figure 1. Students' Creative Answers in the GeoGebra-assisted Creative Problem-Solving Model

Table 4.
Data on the Improvement of Mathematical Creative Thinking Ability

	GeoGebra-CPS Group	CPS Group
Number of Students	29 Students	31 Students
Highest Improvement	0.79	0.63
Lowest Improvement	0.37	0.27

In Table 4, it is shown that the GeoGebra-CPS group had the highest improvement of 0.79 and the lowest improvement of 0.37. Meanwhile, the CPS group had the highest improvement of 0.63 and the lowest improvement of 0.27.

Based on these improvement data, a comparative test was conducted to analyze the increase in mathematical creative thinking ability. The results of the comparative improvement test are presented in Table 5.

p-ISSN: 2086-4280
e-ISSN: 2527-8827

Table 5.
Results of the Test on Differences in the Improvement of Mathematical Creative Thinking Ability

Group	Mean ($\bar{x}$)	Variance (s^2)	t_calculated	t_table	Interpretation
Geogebra-CPS	0.5388	0.0135	1.5562	2.0017	Fail to reject H_0
CPS	0.4952	0.0102			

After conducting the *t*-test on the improvement data of the two groups, the calculated *t*-value (t_calculated) was 1.5562 and the critical *t*-value (t_table) was 2.0017. The decision criterion for accepting H_0 is if it satisfies the condition $-t\_table \leq t\_calculated \leq t\_table$. Since $-2.0017 \leq 1.5562 \leq 2.0017$, H_0 is accepted. This means that the improvement in students' creative thinking ability through learning assisted by GeoGebra software using the CPS learning model is equal to the improvement in students' creative thinking ability using only the CPS learning model. In other words, there is no significant difference in the improvement of mathematical creative thinking ability between the GeoGebra-CPS group and the CPS group. Next, a more detailed analysis was conducted on the improvement of mathematical creative thinking ability based on the specific indicators of mathematical creative thinking itself. The improvement data is presented in Table 6.

Table 6.
Improvement Data of Mathematical Creative Thinking Ability Based on Indicators

Group	Fluency	Flexibility	Originality	Elaboration
GeoGebra-CPS Group				
Lowest Improvement	0.0588	0.3000	0.2500	0.5000
Highest Improvement	0.7500	1.0000	0.7778	1.0000
Mean ($\bar{x}$)	0.3905	0.5511	0.4971	0.7051
CPS Group				
Lowest Improvement	0.0000	0.2500	0.2500	0.4167
Highest Improvement	0.4500	0.8824	0.6875	0.9286
Mean ($\bar{x}$)	0.1509	0.6414	0.5167	0.6459

Based on the improvement data for each indicator of mathematical creative thinking ability in Table 6, a test of mean equality was conducted to determine which indicators showed significant differences in improvement. The results of the test are presented in Table 7.

Table 7.
Results of Differences in the Improvement of Mathematical Creative Thinking Ability Based on Indicators

Indicator	Test Result	Interpretation
Fluency	Mann-Whitney U = 130.5	Accept Ha (Reject H0)
	Sig. (2-tailed) = 0.000	
Flexibility	Mann-Whitney U = 271.5	Accept Ha (Reject H0)
	Sig. (2-tailed) = 0.008	
Originality	t_calculated = -0.6384	Accept H0
	t_table = 2.0017	
Elaboration	t_calculated = 1.6914	Accept H0
	t_table = 2.0017	

Based on Table 7, it is known that significant differences exist in the improvement of mathematical creative thinking ability for the fluency and flexibility

indicators. In contrast, there are no significant differences in the originality and elaboration indicators. Looking at the average scores of the two groups, it is found that the GeoGebra-CPS group showed better improvement in the fluency indicator, while the CPS group showed better improvement in the flexibility indicator. Based on the comparison of the classification recapitulation of mathematical creative thinking ability levels in the GeoGebra-CPS and CPS groups, the results are as follows in Table 8.

Table 8.
Recapitulation of the Improvement of Mathematical Creative Thinking Ability

Group	MCTAL Classification	Before (Pretest)	After (Posttest)
		Students	Percentage (%)
GeoGebra-CPS	Not Creatif	12	41
	Less Creative	12	41
	Moderately Creative	5	17
	Creative	0	0
	Highly Creative	0	0
CPS	Not Creatif	16	52
	Less Creative	14	45
	Moderately Creative	1	3
	Creative	0	0
	Highly Creative	0	0

Table 8 shows that after receiving the treatment, both the GeoGebra-CPS and CPS groups experienced an improvement in mathematical creative thinking ability with no significant difference between them. However, at the highly creative level, the GeoGebra-CPS group reached 10% after the treatment, whereas the CPS group did not. Although it is only 10%, this indicates that the treatment provided to the GeoGebra-CPS group can enhance students' creative thinking ability to a highly creative level.

3) Students' Responses Toward GeoGebra Software Media.

Table 9.
Recapitulation of the Improvement in Mathematical Creative Thinking Ability

Classification	Number of Students	Percentage (%)
Fair	1	4
Good	5	17
Very Good	23	79

Table 9 shows that 79% of students responded very well, 17% responded well, and 4% showed a sufficient response to the use of GeoGebra software.

b. Discussion

This study provides a deeper analysis of the factors influencing the learning outcomes of both experimental groups. While both groups generally showed positive improvements, significant differences emerged when evaluated based on the indicators of creative thinking, specifically in the aspects of fluency and flexibility.

The fluency indicator pertains to the students' ability to generate numerous ideas, answers, and problem-solving approaches smoothly (Munandar, 2014). The test results indicate that the CPS-GeoGebra group outperformed the CPS-PowerPoint group in this regard. The use of GeoGebra software helped students understand the concepts of geometric sequences and series more profoundly. Students can directly verify their answers using GeoGebra, furthermore, the

software can even assist them in solving the problems. This aligns with Simbolon (2020), who states that GeoGebra facilitates the internalisation of mathematical concepts. With a strong conceptual foundation, students found it easier to identify basic elements such as the first term and the ratio. This mature understanding served as the primary asset for them to think fluently and generate various solution plans.

In contrast, the CPS-PowerPoint group tended to receive material passively. Without interactive conceptual reinforcement, they were less accustomed to independently exploring critical variables within a problem.

Flexibility, on the other hand, is the ability to provide varied answers and view problems from different perspectives (Munandar, 2014; Setyaningsih & Kustiana, 2023). In this aspect, the CPS-PowerPoint group showed better improvement compared to the CPS-GeoGebra group. Although GeoGebra eases conceptual understanding, findings suggest a presence of technological dependence. Students in the GeoGebra class tended to input data directly into the application to obtain instant answers. Conversely, the PowerPoint group was accustomed to viewing solution options via slides and performing calculations manually. This manual process encouraged them to explore various alternative methods to find the correct answer. Dependence on tools can limit a student's desire to seek alternative methods (Raihan & Nurzalkinah, 2024), resulting in flexibility scores that were not as high as the group accustomed to manual processes.

Despite the risk of dependency, GeoGebra proved effective as a medium for verifying the accuracy of answers that students had attempted independently. As a supporting tool, GeoGebra accelerates the understanding of essential mathematical elements required to construct logical arguments (Kusumawardani et al., 2018; Afhami, 2022).

IV. CONCLUSION

The creative thinking skills of students taught using the CPS model with GeoGebra showed a significantly greater improvement compared to those taught using the CPS model with PowerPoint. Students in the GeoGebra-assisted group experienced improvements categorized as medium and high, whereas those in the PowerPoint group showed improvements in the medium and low categories.

ACKNOWLEDGEMENT

Gratitude is extended to the Rector of the Institut Pendidikan Indonesia Garut for facilitating the research and the publication of its results.

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