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# EMPOWERING YOUNG THINKERS: ENHANCING COMPUTATIONAL THINKING THROUGH PROBLEM POSING AND GEOGEBRA

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## Abstrak

Meskipun *computational thinking* (CT) semakin ditekankan dalam pembelajaran matematika, masih sedikit penelitian yang mengkaji bagaimana pendekatan problem posing berbantuan teknologi dapat secara efektif meningkatkan kemampuan CT siswa sekolah dasar. Penelitian ini bertujuan untuk mengkaji efektivitas model pembelajaran Problem Posing yang dipadukan dengan bantuan GeoGebra dalam meningkatkan CT siswa kelas V sekolah dasar. Menggunakan desain kuantitatif Interrupted Time Series, penelitian ini melibatkan 24 siswa. Intervensi dilaksanakan selama sepuluh minggu, dengan sebanyak tiga kali per minggu dalam pembelajaran matematika untuk memfasilitasi kegiatan menyusun dan mengeksplorasi masalah secara interaktif. Data dikumpulkan melalui Computational Thinking Test (CT-Test) yang diberikan sebelum dan sesudah intervensi. Hasil penelitian menunjukkan peningkatan skor rata-rata dari 69,38 (pre-test) menjadi 83,54 (post-test), dengan perbedaan yang signifikan secara statistik berdasarkan uji paired sample t-test ($p < 0{,}001$). Kinerja berdasarkan indikator CT menunjukkan peningkatan tertinggi pada aspek abstraksi dan generalisasi, sementara debugging menjadi yang terendah. Analisis berdasarkan gender menunjukkan bahwa siswa perempuan sedikit lebih unggul dari siswa laki-laki dalam skor post-test, meskipun keduanya mengalami peningkatan yang signifikan. Temuan ini menegaskan efektivitas integrasi problem posing dan GeoGebra dalam mengembangkan keterampilan CT siswa, khususnya dalam menyelesaikan soal cerita matematika. Pendekatan ini tidak hanya memperkuat pemahaman konsep, tetapi juga mendukung strategi pembelajaran yang terdiferensiasi.
**Kata kunci:** Berpikir Komputasi; Geogebra; Problem Posing; Sekolah Dasar.

## Abstract

Despite the growing emphasis on computational thinking (CT) in mathematics education, few studies have explored how technology-assisted problem-posing approaches can effectively enhance CT skills among elementary students. This study aims to examine the effectiveness of the Problem Posing learning model assisted by GeoGebra in enhancing CT skills among fifth-grade elementary students. Utilizing a quantitative Interrupted Time Series design, the study involved 24 students. The intervention was implemented over ten weeks, with three mathematics sessions per week to facilitate interactive problem creation and exploration. Data were gathered using the Computational Thinking Test (CT-Test), administered before and after the intervention. The results showed

an increase in the mean score from 69.38 (pre-test) to 83.54 (post-test), with statistically significant differences confirmed by a paired sample t-test ($p < 0.001$). Performance across CT indicators revealed the highest gains in abstraction and generalization, while debugging remained the lowest. Gender-based analysis indicated that female students slightly outperformed males in post-test scores, though both groups demonstrated significant improvement. These findings underscore the effectiveness of integrating problem posing and GeoGebra in fostering students' CT skills, particularly in solving word problems in mathematics. This approach not only promotes conceptual understanding but also supports differentiated learning strategies.
**Keywords**: Computational Thinking; Elementary Education; Geogebra; Problem Posing.

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## INTRODUCTION

CT is a structured approach to reasoning that involves applying concepts and principles derived from computer science to solve problems effectively. This aligns with the idea that CT is a thinking approach related to the ability to solve problems through the application of principles or concepts derived from the field of computing (Mardianto & Yahfizham, 2024). CT skills play a crucial role in the domain of computing as they foster the development of critical, creative, and analytical mindsets. These skills are highly useful in solving various problems, whether related to computing or challenges encountered in everyday life (Manullang & Simanjuntak, 2023). CT includes skills in analyzing, designing solutions, and solving problems systematically. It helps students address problems by simplifying them and stimulating their creativity (Gunawan, Sholikin, Harmonika, & Gaffar, 2022).

CT plays a vital role in helping students enhance their problem-solving skills in mathematics (Syamsy & Sholikhah, 2023). CT involves stages such as formulating problems, finding solutions, and evaluating outcomes based on established indicators of CT (Fang, Ng, & Yuen, 2025; García-Pérez, Roldán-Álvarez, & Cañas, 2025). CT and problem solving are interrelated. This aligns that in CT, students are guided to master critical and creative thinking skills and are trained to communicate and collaborate effectively in tackling various challenges or problems they face (Ansori, 2020).

Various instructional models have been explored to strengthen students' CT skills. One such approach is the scientific-based on problem, which has been proven effective in enhancing students' CT abilities (Chevalier, Giang, Piatti, & Mondada, 2020). However, this research was conducted within the context of informatics subjects at the vocational school, limiting its applicability to elementary mathematics education. Further, the improvement of CT through an Inquiry-Based Learning model (Lestari, 2019). Nonetheless, the study targeted higher educational levels and focused on science subjects, without establishing a direct link to mathematics instruction. Other studies have explored the implementation of the Problem Posing model (Khairunnisa, 2019; Nugroho & Anugraheni, 2021; Rustina, 2016), yet these were primarily designed to assess critical and creative thinking skills at secondary and tertiary education levels. Thus, further investigation is needed to determine how the Problem Posing model can effectively nurture CT, particularly in solving mathematical word problems at the elementary level.

The Problem Posing model is a learning approach that engages students more actively and fosters the development of critical thinking skills, ultimately enabling them to solve mathematical problems (Shanty, Hartono, Putri, & de Haan, 2011). This model emphasizes students' ability to formulate, pose, and solve problems. Through Problem Posing, students gain opportunities to deepen their understanding of subject matter while also enhancing their creativity, critical thinking, and problem-solving skills (Nur, 2018). Therefore, integrating Problem Posing into elementary mathematics provides a pedagogical pathway to enhance CT through meaningful engagement with contextual mathematical tasks.

Besides instructional model, instructional media play an important role in facilitating understanding and supporting student engagement. Instructional media supporting teaching and learning processes by clarifying the delivery of content and facilitating the achievement of learning objectives in an optimal and efficient manner (Nurfadhillah, Barokah, Nur'alfiah, Umayyah, & Yanti, 2021). GeoGebra, as a dynamic mathematics application, allows learners to interact directly with geometric figures, graphs, and algebraic representations (Lubis, 2024). GeoGebra significantly enhances students' CT skills by enabling direct interaction with geometric representations, graphs, and algebraic expressions (Sitorus et al., 2024). GeoGebra provides concrete learning experiences that deepen student understanding (Ghozi, 2015). Various studies also suggest that GeoGebra supports student exploration and experimentation during classroom activities (Suhaifi & Karyono, 2021). In this study, the researcher integrates digital media within the Problem Posing model to maximize its potential in enhancing students' CT when solving mathematical word problems related to plane figures.

Although previous studies have independently demonstrated the benefits of Problem Posing and GeoGebra, limited research has explored their integration to foster CT in elementary mathematics. The present study addresses this gap by investigating the effectiveness of the Problem Posing learning model assisted by GeoGebra in enhancing the CT skills of fifth-grade students. Specifically, it focuses on students' ability to solve mathematical word problems related to plane figures. Through a structured quantitative intervention, the study aims to measure improvements across key CT indicators—abstraction, decomposition, generalization, algorithmic thinking, and debugging—resulting from this integrated pedagogical approach.

The primary objective of this study is to investigate the effectiveness of the Problem Posing learning model integrated with GeoGebra media in enhancing the computational thinking abilities of fifth-grade elementary students. Specifically, the study focuses on students' performance in solving mathematical word problems related to the topic of plane figures. To achieve this, the research will implement a quantitative approach, where students will be given a series of structured learning interventions. The intervention combines the interactive features of GeoGebra with the student-centered nature of the Problem Posing model to engage learners in problem formulation, exploration, and solution processes. The study aims to measure the extent to which this integrated instructional approach contributes to improvements across key computational thinking indicators, including abstraction, decomposition, generalization, algorithmic thinking, and debugging.

## METHOD

### Design and Procedure of Research

This study employed a quantitative approach, chosen because the data were measured through operationalized variables using instruments that yielded interval-scale data, which are essential for accurately assessing differences in students' computational thinking abilities. The research used a time series design, involving a single class that functioned as both the control and experimental group. No random sampling or control group was used; instead, data collected before the intervention served as control data, while data collected after the intervention were considered experimental (see Figure 1). The study adopted the Interrupted Time Series Design (Creswell, 2011). The study began with the selection of participants, ensuring that all students met the inclusion criteria for the intervention. Following this, students undertook the Computational Thinking Test (CT-Test) as the initial assessment to measure their baseline CT skills. After the pre-test, a 10-week intervention was conducted using the Problem Posing learning model integrated with GeoGebra. During this phase, students were actively engaged in generating, exploring, and solving mathematical problems within interactive learning sessions. Table 1 presents the classification of the 10-week Problem Posing intervention assisted by GeoGebra, consisting of three mathematics sessions per week. The intervention was structured into four phases: orientation and baseline activities (Weeks 1–2), problem generation and exploration (Weeks 3–5), solution design and algorithmic thinking (Weeks 6–8), and debugging and reflection (Weeks 9–10). Each phase emphasized specific computational thinking components—such as abstraction, decomposition, generalization, algorithmic thinking, and debugging—through interactive learning tasks that engaged students in creating, solving, and refining mathematical problems using GeoGebra. Upon completion of the intervention, students completed the CT-Test (final test) to evaluate the development of their CT abilities. Finally, the collected data were subjected to improvement analysis to determine the effectiveness of the intervention by comparing the pre-test and post-test results. This design reflects a structured and systematic approach to assessing the impact of Problem Posing-based instruction on students' computational thinking development over time.

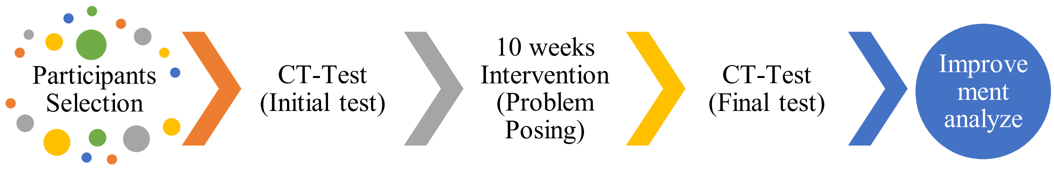


**Figure 1. Research Design of Problem Posing Intervention to Computational Thinking**

**Table 1. Classification of the 10-Week Problem Posing Intervention with GeoGebra**

| Weeks | Focus of Learning | Main CT Components | Learning Activities (3 Sessions per Week) |
|---|---|---|---|
| 1–2 | Orientation and Baseline Activities | Abstraction, Decomposition | Introduction to computational thinking and GeoGebra tools.<br>Exploration of plane figure concepts (area, perimeter).<br>Guided formulation of simple mathematical problems. |
| 3–5 | Problem Generation and Exploration | Abstraction, Decomposition, Generalization | Students create and modify word problems related to plane figures.<br>Use GeoGebra to visualize and manipulate geometric shapes.<br>Collaborative discussion on various problem structures. |

| Weeks | Focus of Learning | Main CT Components | Learning Activities (3 Sessions per Week) |
|---|---|---|---|
| 6–8 | Solution Design and Algorithmic Thinking | Algorithmic Thinking, Generalization | Students develop step-by-step algorithms to solve their own problems.<br>Comparison of multiple solution strategies.<br>Application of GeoGebra simulations for validation and experimentation. |
| 9–10 | Debugging and Reflection | Debugging, Evaluation, Integration | Identification and correction of errors in problem formulation or solutions.<br>Reflection on computational strategies and problem-solving processes.<br>Practice sessions and preparation for the final CT-Test. |

**Participant**

The study involved 24 fifth-grade students from a public elementary school located in an urban area of East Java, Indonesia. The group consisted of 9 male and 15 female students, representing a range of demographic backgrounds. Participants varied in academic achievement levels, learning styles, and levels of access to digital technology at home. Several students had prior exposure to digital learning tools, while others were relatively new to using educational technology such as GeoGebra. The participants also demonstrated diverse levels of engagement and motivation in mathematics learning. All students took part in the same instructional intervention designed to enhance their computational thinking skills through the integration of the Problem Posing model and GeoGebra media in solving mathematical word problems. The diversity among participants allowed the study to capture a broad range of responses to the instructional model being tested.

**Instruments**

In this study, data were collected using an instrument called the Computational Thinking Test (CT-Test), which was developed to measure students' computational thinking skills in fifth-grade mathematics, specifically focusing on the topic of calculating the perimeter of plane figures. The CT-Test was administered in two stages: a pre-test conducted before the instructional intervention, and a post-test given after the intervention. The pre-test aimed to assess students' initial abilities, while the post-test measured their progress across five computational thinking indicators: abstraction, generalization, decomposition, algorithmic thinking, and debugging, as presented in Table 2. Specifically, the CT-test consists of geometry word problems related to two-dimensional shapes, each requiring students to analyze a contextual scenario and apply CT processes to generate a solution. The problems were designed to reflect real-life situations involving composite shapes, perimeter, area, and various measurement tasks. The structure of the questions ensured that students were not only computing numerical answers but also demonstrating their reasoning processes.

The CT-Test consisted of two open-ended (essay) questions and was designed to be completed within 30 minutes. To ensure the instrument's quality, both validity and reliability procedures were conducted prior to the main study. For content validity, the instrument was reviewed by two expert validators in the fields of mathematics education and educational technology. Revisions were made based on their feedback until the instrument was deemed appropriate. Reliability testing was conducted through a pilot study involving a group of students from a different elementary school with similar characteristics. The reliability of the CT-Test was calculated using the Cronbach's Alpha formula, resulting in a coefficient of $\alpha$ = 0.881, indicating that the instrument had high internal consistency and was reliable for use in the study.

**Table 2. Indicators of Computational Thinking Skills Measured in the CT-Test**

| Indicator | Operational Definition | Sample Task / Question Focus |
|---|---|---|
| Abstraction | The ability to identify relevant information and ignore unnecessary details in a problem. | Identifying known and unknown elements from a word problem on perimeter. |

| Indicator | Operational Definition | Sample Task / Question Focus |
|---|---|---|
| Decomposition | The ability to break down a complex problem into smaller, manageable parts. | Dividing a composite shape into simpler shapes to calculate total perimeter. |
| Generalization | The ability to recognize patterns and apply previous knowledge to new situations. | Applying perimeter formulas of standard shapes to solve unfamiliar problems. |
| Algorithmic Thinking | The ability to design a clear, step-by-step solution to a problem. | Writing or explaining steps to solve a word problem involving measurements. |
| Debugging | The ability to identify and correct errors in a solution process. | Reviewing a solution and identifying miscalculations or logical mistakes. |

### Data analysis

The data analysis in this study aimed to assess the effectiveness of the Problem Posing learning model supported by GeoGebra media in enhancing students' computational thinking (CT) skills in solving mathematical word problems on plane figures. A quantitative approach using an Interrupted Time Series Design was applied, and data were collected through pre-test and post-test using the CT-Test instrument. Descriptive statistics (mean, minimum, maximum, standard deviation) and inferential statistics (paired sample t-test) were used, with a significance level set at $\alpha = 0.001$.

## RESULT AND DISCUSSION

### Overall Performance and Across Indicators

Based on the quantitative data collected through pre-test and post-test assessments, there was a significant improvement in students' computational thinking (CT) abilities following the implementation of the Problem Posing learning model assisted by GeoGebra. The average pre-test score was 69.38, while the post-test yielded an improved average score of 83.54. This 14.16-point increase indicates that the intervention had a positive impact on students' ability to solve mathematical word problems using computational thinking. Furthermore, the standard deviation decreased from 18.14 in the pre-test to 13.39 in the post-test, suggesting increased consistency and a reduced spread in students' performance. All data presented in Tabel 3.

Further analysis was conducted on the five indicators of computational thinking, namely abstraction, generalization, decomposition, algorithmic thinking, and debugging. The results showed improvement in all indicators. The average score for abstraction increased from 4.20 to 4.80, generalization from 3.25 to 3.90, decomposition from 2.60 to 3.30, algorithmic thinking from 2.41 to 3.00, and debugging from 1.41 to 1.90 (see Figure 2). The most substantial gains were observed in the indicators of generalization and decomposition, indicating that students became more capable of identifying patterns and breaking problems into manageable components after participating in the learning intervention. Although debugging remained the lowest among the five indicators, it still showed notable improvement, reflecting growth in students' ability to detect and correct errors during problem solving. Overall, these findings suggest that the Problem Posing model supported by GeoGebra effectively enhances both the general and specific aspects of students' computational thinking skills.

**Table 3. Descriptive Statistics and Mean Scores of Computational Thinking Indicators**

| Component | Pre-test | Post-test |
|---|---|---|
| Number of Respondents (N) | 24 | 24 |
| Mean Score | 69.38 | 83.54 |
| Median | 70.00 | 85.00 |
| Minimum Score | 30.00 | 50 |
| Maximum Score | 100.00 | 100 |
| Standard Deviation | 18.14 | 13.39 |
| Variance | 328.90 | 179.30 |

| Component | Pre-test | Post-test |
|---|---|---|
| Computational Thinking Indicators | | |
| Abstraction | 4.20 | 4.80 |
| Generalization | 3.25 | 3.90 |
| Decomposition | 2.60 | 3.30 |
| Algorithmic Thinking | 2.41 | 3.00 |
| Debugging | 1.41 | 1.90 |

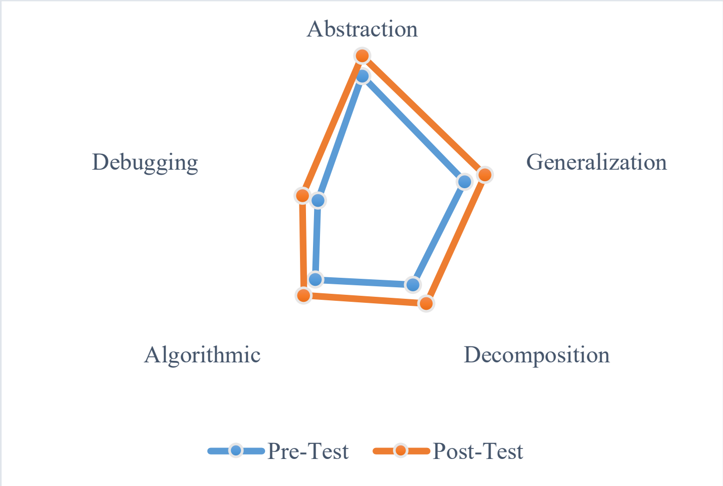


**Figure 2. Performance Across Indicators**

**Performance Across Gender**

The analysis of students' computational thinking performance across gender provides insight into how male and female students performed before and after the implementation of the Problem Posing model assisted by GeoGebra. The group consisted of 9 male and 15 female students. The mean pre-test score for male students was 70.22, while female students had an average of 68.73. After the intervention, the mean post-test score for male students increased to 84.44, whereas female students achieved a mean score of 82.93. These results indicate that both male and female students experienced improvement in their computational thinking abilities after participating in the intervention. Although male students demonstrated a slightly higher average gain, the overall progress across both genders suggests that the Problem Posing model supported by GeoGebra was effective in enhancing computational thinking skills in solving mathematical word problems regardless of gender.

**The Effectiveness of Problem Posing with GeoGebra**

To examine the effectiveness of the Problem Posing learning model assisted by GeoGebra, a paired sample t-test was conducted to compare students' computational thinking scores before and after the intervention. The analysis involved 24 fifth-grade students who participated in both the pre-test and post-test. The mean score on the pre-test was 69.38, while the post-test mean increased to 83.54, indicating an improvement in performance following the implementation of the learning model. The results of the paired sample t-test revealed a statistically significant difference between the two tests, with $t(23) = -6.94$ and $p < 0.001$. The mean difference was -14.17 with a standard deviation of 10.059. It can be concluded that the Problem Posing learning model assisted by GeoGebra had a significant positive effect on students' computational thinking abilities in solving mathematical word problems.

**Discussion**

Based on research conducted at an elementary school in Madiun Regency, it was found that the application of the Problem Posing model significantly improved students' computational thinking abilities. This effectiveness was reflected in the results of computational thinking tests in the context of mathematics learning. This finding aligns with Problem Posing is considered an appropriate approach to enhance students' problem-solving skills in mathematics, surpassing the effectiveness of several other models (Tanjung, Ardiana, & Harahap, 2020). Teachers choose this model because it is seen as capable of stimulating various student skills, such as speaking, listening, conceptual understanding, as well as designing and solving problems independently. This is supported by previous research which showed that the Problem Posing model proved to be more effective than the Problem Solving model, particularly in developing students' critical thinking abilities in mathematics learning (Wulandari, Dantes, & Antara, 2020). This contrasts with the Problem-Based Learning model and noted that students were not given sufficient emphasis on the formation of initial understanding, making the learning process less focused on building strong conceptual foundations from the start (Yusri, 2018).

In this study, the Problem Posing model was used to encourage analytical thinking by linking learning concepts to real-life situations, enabling students to build a deeper conceptual understanding. This is in line that the Problem Posing model allows students to independently create and formulate problems (Evi & Indarini, 2021). Students are expected to utilize the concepts they have learned to design problems, which they can then solve themselves or present to their peers. Further, the application of the Problem Posing model promotes active student engagement in the learning process by encouraging them to formulate their own questions and respond to questions posed by their classmates (Arianti, Wiarta, & Darsana, 2019). Students who are not used to competition may face challenges in participating optimally in the learning process.

The use of an appropriate learning model plays an important role in classroom instruction. The choice of the Problem Posing model in teaching mathematics, specifically in solving word problems among fifth-grade students, demonstrated that learning processes can positively influence students' skills and achievement. This is supported by the studies that selecting an appropriate learning model can encourage the development of students' problem-solving abilities (Wawat, 2022). Effective models such as Problem Posing enhance students' skills by giving them responsibility and encouraging the courage to formulate and solve problems based on available information. Problem Posing model provides space for students to ask questions about concepts they do not understand and to design as many problems as possible based on given situations and present them to the class (Astriyani, 2016).

In contrast, mathematics instruction in schools often lacks adequate opportunities for students to develop problem-solving skills due to teachers' limited practice in actively involving students in solving complex problems during lessons (Asfar & Nur, 2018). A learning model that aligns with the indicators of computational thinking particularly in formulating and solving mathematical problems is the Problem Posing model.

In this study, the Problem Posing model proved effective in boosting students' enthusiasm during mathematics lessons. When integrated into the teaching process, the Problem Posing model improved students' computational thinking in solving mathematical word problems, both independently and in collaboration. Combining the Problem Posing model with the use of GeoGebra media enhanced the quality and effectiveness of students' computational thinking during learning. Learning media are critical in supporting the success of the teaching-learning process, as they help teachers convey information and facilitate communication between teachers and students (Wati, 2022). The media used in this study was tailored to the lesson on two-dimensional shapes in mathematical word problems. GeoGebra helps students to think actively during the learning process. GeoGebra is a highly useful teaching tool that delivers lessons in a way that is engaging and less monotonous (Permaganti, Rahayu, & Setiawan, 2019). GeoGebra in geometry lessons increased student interest in the material, as it enabled them to apply ideas and gain meaningful learning experiences through problem-solving activities (Chytas, van Borkulo, Drijvers, Barendsen, & Tolboom, 2024; Wati, 2022). Throughout the learning process, students were also given opportunities to be actively involved.

GeoGebra, as a digital medium, has the potential to influence and improve students' computational thinking skills, especially in learning about geometric figures. Interactive digital media can create a more engaging and enjoyable learning atmosphere, thereby increasing students' enthusiasm and participation (Putri, Tanjung, & Siregar, 2024). This contrasts with the studies that uses concrete media as adapting enactif theory (Akkan, 2012; Marshall, Taylor, Hothersall, & Pérez-

Martín, 2011). Their research found that students were sometimes distracted by the physical media and failed to pay attention to teacher instructions, leading to classroom disruption and a non-conducive learning environment. Teachers initially believed concrete media were more effective in conveying mathematical concepts, their perceptions changed after using digital media and observing students' responses and engagement (Golafshani, 2013). They began to recognize the potential of digital media in enhancing student understanding.

This study integrated the Problem Posing model with GeoGebra as a learning medium. GeoGebra not only facilitated interaction between teachers and students but also improved the quality of instruction in solving word problems related to geometric shapes. GeoGebra serves at least three functions: as a teaching medium, a tool for developing teaching materials, and as a tool for solving mathematical problems (Mulbasari, 2017). GeoGebra can transform students' thinking in approaching mathematical word problems, fostering a more active, creative, and enjoyable learning experience to achieve learning objectives. GeoGebra enables students to directly interact with geometric, graphical, and algebraic representations, strengthening their understanding through concrete learning experiences (Ghozi, 2015).

Teaching mathematics using the Problem Posing model supported by GeoGebra encourages greater student participation throughout the learning process. Problem Posing model is a teaching strategy that actively engages students and enhances their critical thinking, ultimately enabling them to solve mathematical problems (Shanti & Abadi, 2015). The use of GeoGebra in this study also increased student engagement, particularly when learning about two-dimensional shapes. GeoGebra is a useful application for teaching mathematics especially geometry and that its use positively influences student learning outcomes.

## CONCLUSION

The integration of the Problem Posing learning model with GeoGebra media has proven effective in enhancing the computational thinking skills of fifth-grade elementary students. The findings demonstrate a significant improvement in students' ability to analyze problems, generate solutions, and apply mathematical concepts in meaningful contexts. This approach fosters student engagement, encourages active participation, and facilitates deeper conceptual understanding, particularly in geometry-related word problems. The use of GeoGebra as a digital interactive tool further supports visualization and problem construction processes, making mathematics learning more dynamic and student-centered.

This study was limited to a single class of 24 fifth-grade students in one elementary school, which may affect the generalizability of the findings. Additionally, the focus was specifically on two-dimensional shape problems, so the effectiveness of the intervention on other mathematical topics remains unexplored. The duration of the intervention was relatively short, and long-term impacts on students' computational thinking skills could not be assessed. Future research should involve larger and more diverse student populations across different grade levels and schools to validate and expand upon the findings. It is also recommended to explore the application of the Problem Posing model with GeoGebra media in other mathematical domains such as number operations, measurement, or data handling. Finally, longitudinal studies could be conducted to examine the sustained impact of the intervention on students' computational thinking development over time.

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