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Exploring the Role of ChatGPT in Enhancing Students' Mathematical Creative Thinking in Geometry Learning: A Qualitative Case Study

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Abstrak

Pikiran kreatif merupakan kompetensi kunci dalam pembelajaran geometri, yang sering melibatkan pemecahan masalah yang tidak rutin dan secara visual kompleks, namun banyak siswa mengalami kesulitan dalam mengembangkan strategi pemecahan masalah. Peningkatan penggunaan kecerdasan buatan generatif seperti ChatGPT menawarkan peluang pedagogis baru, namun perannya dalam mendukung pemikiran kreatif matematis masih belum jelas. Studi ini bertujuan untuk mengkaji bagaimana keterkaitan pembelajaran yang didukung ChatGPT terhadap pemikiran kreatif matematis siswa dalam geometri dan menganalisis karakteristik pemecahan masalah siswa saat didukung oleh AI. Studi kasus kualitatif dilakukan dengan 29 siswa kelas tujuh dari SMP di Kampar. Data dikumpulkan melalui Tes Kemampuan Berpikir Kreatif Matematika dengan empat soal geometri non-rutin, observasi kelas, dan analisis tanggapan tertulis siswa, yang dievaluasi menggunakan indikator berpikir kreatif matematika. Temuan menunjukkan bahwa berpikir kreatif siswa berada pada tingkat sedang, dengan ChatGPT paling efektif dalam mendukung elaborasi, sementara fleksibilitas dan orisinalitas tetap relatif lemah. Kesalahan utama terjadi pada tahap keterampilan transformasi dan proses, terutama dalam tugas visual-spasial. ChatGPT berfungsi sebagai scaffolding prosedural dan elaboratif rather than katalisator untuk pemikiran divergen, menyoroti kebutuhan akan integrasi AI yang terarah dan reflektif dalam pembelajaran geometri.
***Kata kunci**: ChatGPT; Berpikir kreatif matematis; pembelajaran geometri; studi kasus kualitatif.*

Abstract

Creative thinking is a key competency in geometry learning, which often involves solving non-routine and visually complex problems, yet many students struggle to develop problem-solving strategies. The increased use of generative artificial intelligence such as ChatGPT offers new pedagogical opportunities, but its role in supporting mathematical creative thinking remains unclear. This study aims to examine how ChatGPT-supported learning relates to students' mathematical creative thinking in geometry and to analyse the characteristics of students' problem solving when supported by AI. A qualitative case study was conducted with 29 seventh-grade students from a secondary school in Kampar. Data were collected through a Mathematical Creative Thinking Ability Test with four non-routine geometry questions, classroom observations, and analysis of students' written responses, which were evaluated using indicators of mathematical creative thinking. Findings indicate that students' creative thinking is at a moderate level, with ChatGPT most effective in supporting elaboration, while flexibility and originality remain relatively weak. The main errors occurred at the transformation and process skill stages, especially in visual-spatial tasks. ChatGPT functioned as procedural and elaborative scaffolding rather than a catalyst for divergent thinking, highlighting the need for targeted and reflective AI integration in geometry learning.
Keywords: ChatGPT; mathematical creative thinking; geometry learning; qualitative case study.

I. INTRODUCTION

The rapid advancement of artificial intelligence (AI) has profoundly transformed various sectors, including education. Among recent AI innovations, ChatGPT, a generative artificial intelligence system built upon large language models (LLMs) and the Generative Pre-trained Transformer (GPT) architecture, has attracted significant scholarly attention due to its capacity to generate coherent, context-aware, and human-like textual responses. Since its public release in late 2022, ChatGPT has been increasingly explored as a pedagogical tool capable of supporting learning processes across disciplines, particularly in mathematics education (Bhattacharya et al., 2023; Giannos & Delardas, 2023; Kikalishvili, 2024). Its interactive and adaptive nature offers opportunities to enhance student engagement, personalize learning experiences, and scaffold higher-order cognitive skills.

In mathematics education, creative thinking is widely recognized as a core competency that enables learners to generate multiple solution strategies, construct novel ideas, and elaborate mathematical reasoning when solving complex or non-routine problems. Creative thinking encompasses several interrelated dimensions, including fluency, flexibility, originality, and elaboration, which collectively support meaningful mathematical understanding and problem-solving performance (Fineldi et al., 2025; Gunawan et al., 2022; Suherman & Vidákovich, 2024). These dimensions are particularly critical in geometry learning, a domain that requires spatial reasoning, visualization, and the integration of conceptual and procedural knowledge. However, numerous studies have reported that students often demonstrate limited creative thinking abilities in geometry, especially when confronted with open-ended or visually complex tasks that impose a high cognitive load (Çakıroğlu & Yıldırım, 2024; Jupri & Hidayat, 2022).

Recent literature suggests that AI-based tools such as ChatGPT have the potential to support creative thinking by fostering divergent thinking, offering alternative perspectives, and providing step-by-step explanations that may reduce cognitive barriers during problem solving (Habib et al., 2024; Thomas et al., 2024). In educational contexts, ChatGPT has been shown to facilitate personalized learning, enhance motivation, and assist learners in organizing ideas and articulating reasoning processes (Al-Emran, 2024; Baidoo-Anu & Owusu Ansah, 2023). Several empirical studies have reported positive effects of ChatGPT on students' critical and creative thinking skills, including increased flexibility and originality in problem-solving tasks (Qawqzeh, 2024; Toma & Yánez-Pérez, 2024). These findings indicate that generative AI can function as a cognitive scaffold that complements traditional instructional approaches.

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Nevertheless, the integration of ChatGPT into mathematics education is not without challenges. Concerns have been raised regarding students' overreliance on AI-generated responses, the risk of superficial understanding, and the potential erosion of independent thinking skills (Alvarez, 2024; Kaitharath et al., 2024). Moreover, several studies have documented instances in which ChatGPT produces mathematically plausible yet conceptually incorrect solutions, particularly in tasks involving diagrams, spatial representations, or abstract geometric reasoning (Arista et al., 2023; Mohammad et al., 2023). Such limitations underscore the importance of critical evaluation and human–AI collaboration, where learners actively assess and refine AI-generated outputs rather than adopting them uncritically (Canonigo, 2024; Rospigliosi, 2023).

Despite the growing body of research on ChatGPT in education, existing studies predominantly focus on higher education contexts, language learning, or general problem-solving skills. Empirical evidence examining the role of ChatGPT in supporting mathematical creative thinking at the secondary school level, particularly within geometry learning, remains scarce. More importantly, limited attention has been given to comparing the cognitive characteristics of solutions generated by ChatGPT with those produced by students who use ChatGPT as a learning aid. This gap restricts a deeper understanding of how AI-assisted learning shapes students' creative thinking processes and where its pedagogical boundaries lie.

Addressing this gap, the present study explores the use of ChatGPT in junior secondary geometry learning with a specific focus on students' mathematical creative thinking abilities. Unlike prior studies that primarily assess learning outcomes, this research emphasizes a qualitative examination of students' solution processes across the dimensions of fluency, flexibility, originality, and elaboration, while simultaneously contrasting them with ChatGPT-generated solutions. This approach offers a novel contribution by revealing not only the extent to which ChatGPT supports creative thinking, but also the types of misconceptions or cognitive dependencies that may emerge during AI-assisted problem solving.

The urgency of this research is grounded in both theoretical and practical considerations. From a theoretical perspective, understanding how AI tools interact with creative thinking processes contributes to ongoing discussions on cognitive scaffolding, self-regulated learning, and human–AI collaboration in mathematics education (Groeneveld et al., 2023; Redifer et al., 2021). From a practical standpoint, educators require empirical guidance on how to integrate ChatGPT responsibly into geometry instruction without undermining students' conceptual understanding or creative autonomy. Given

the increasing accessibility of generative AI tools in classrooms, evidence-based insights are essential to inform pedagogical decision-making and curriculum design.

Accordingly, this study aims to investigate the influence of ChatGPT-assisted learning on students' mathematical creative thinking in geometry and to examine students' perceptions of its strengths and limitations. The study is guided by the following research questions: (1) How does the use of ChatGPT in geometry learning influence students' mathematical creative thinking abilities across the dimensions of fluency, flexibility, originality, and elaboration? (2) What strengths, challenges, and pedagogical implications emerge from students' experiences of using ChatGPT as a learning aid in geometry?

II. METHOD

This study employed a descriptive qualitative research design with a case study approach to explore students' mathematical creative thinking in geometry learning supported by ChatGPT. A qualitative descriptive design was considered appropriate because the study aimed to provide a detailed portrayal of students' thinking processes and learning experiences in an authentic classroom context rather than to establish causal relationships or generalize findings statistically (Nassaji, 2015). The case study approach enabled an in-depth examination of a bounded educational setting within a specific time frame, allowing the researchers to capture the complexity of students' interactions with ChatGPT during geometry problem solving (Cassidy et al., 2013; Yin, 2013).

This study was conducted in the even semester of the 2024/2025 academic year at a junior high school in Kampar Regency, Indonesia. The research participants consisted of 29 seventh-grade students aged between 13 and 15 years old who were selected through purposive sampling based on teachers' suggestions and input. This sampling technique was used to ensure that all participants were actively engaged in geometry learning and represented varying levels of mathematical ability and prior exposure to AI tools. The geometry content focused on plane figures, particularly quadrilaterals, which had been previously introduced in regular classroom instruction. In this study, ChatGPT was integrated as a supportive learning technology to assist students in clarifying concepts, exploring solution ideas, and articulating reasoning, rather than serving as a substitute for teacher instruction or students' independent thinking.

Prior to data collection, students were given an orientation session on the appropriate and ethical use of ChatGPT for learning purposes. During the learning activities, students interacted with ChatGPT under teacher supervision using guided prompts designed to encourage explanation, reflection, and comparison of

solution strategies. Students were allowed to pose follow-up questions to ChatGPT; however, they were explicitly instructed to verify AI generated responses using their own reasoning and geometric representations. This instructional arrangement was intended to minimize uncritical reliance on AI output and to promote reflective human AI collaboration, as recommended in recent educational AI literature.

The primary instrument was the researcher, who was responsible for designing the learning activities, administering research instruments, conducting classroom observations, and interpreting the data. To support data collection, a Mathematical Creative Thinking Ability Test was developed as a diagnostic instrument. The test consisted of four non-routine, open-ended geometry problems, each aligned with one indicator of mathematical creative thinking: fluency (the ability to generate more than one valid solution), flexibility (the ability to employ different strategies or approaches), originality (the ability to produce uncommon or novel solutions), and elaboration (the ability to develop ideas in a detailed, coherent, and well-structured manner). The use of non-routine problems was intended to elicit creative reasoning rather than routine procedural responses.

Before implementation, the test items underwent content validation by two experts in mathematics education. The degree of agreement between the experts regarding item relevance was examined using Aiken's V coefficient (Aiken, 1985). The analysis showed that all test items met the validity criteria, with Aiken's V values ranging from 0.80 to 0.95, indicating that the items were appropriate for assessing students' mathematical creative thinking abilities. This validation process strengthened the credibility of the diagnostic instrument used in the study.

Data were collected through multiple sources, including the creative thinking test, classroom observations, and documentation of students' written responses. Classroom observations focused on students' problem-solving behaviors, their patterns of interaction with ChatGPT, and indications of creative thinking during learning activities. Students' written responses were collected to examine how they generated, modified, or adopted solution ideas when assisted by ChatGPT. The use of multiple data sources enabled triangulation, thereby enhancing the trustworthiness of the findings.

Data analysis was conducted using an analytical framework based on students' written answers according to four indicators of mathematical creative thinking. This analysis provided diagnostic insight into the types of errors that emerged when students solved geometry problems with ChatGPT support. In addition, qualitative data were analyzed following the procedures proposed by Miles & Huberman (1994), which include data reduction, data display, and

conclusion drawing. Through iterative analysis and constant comparison across data sources, a comprehensive understanding of students' mathematical creative thinking and the role of ChatGPT in geometry learning was developed.

Ethical considerations were carefully addressed throughout the study. Permission to conduct the research was obtained from the school, and informed consent was secured from students. Students' participation was voluntary, and all data were anonymized to ensure confidentiality. The use of ChatGPT was conducted under teacher supervision to ensure age-appropriate, responsible, and safe interaction with generative AI technologies.

III. RESULT AND DISCUSSION

This section presents the findings of the study concerning students' mathematical creative thinking abilities in geometry learning supported by ChatGPT. The presentation of results focuses on empirical findings derived from diagnostic tests, observations, and written student responses, without interpretative discussion, which is provided in the subsequent section.

A. Descriptive Quantitative

Table 1.
Mean Scores of Mathematical Creative Thinking Ability per Item

Question	Maximum Score	Score $\bar{x}$	Score %
1	4	2,17	54
2	4	1,86	47
3	4	2,48	62
4	4	1,97	49
Total	16	8,48	
Overall Average		2,12	53

Table 1 presents the mean scores of students' mathematical creative thinking ability for each test item, with each item representing one indicator of creative thinking. The overall mean score of 2.12 out of 4 (53%) indicates that students' mathematical creative thinking ability in geometry learning supported by ChatGPT is at a moderate level. This result suggests that students have begun to demonstrate creative reasoning; however, their performance remains uneven across indicators. The highest mean score was obtained on Item 1 (fluency), while the lowest was found on Item 2 (flexibility). This pattern indicates that students were relatively more capable of generating more than one answer than of employing diverse strategies to solve the same problem.

The relatively low score on flexibility implies that although ChatGPT may provide step-by-step explanations, students tend to rely on a single solution pathway rather than exploring alternative approaches. This reliance suggests that the availability of AI-generated guidance does not automatically translate into strategic diversity, particularly in geometry problems that require adaptive reasoning and spatial visualization.

Table 2.
Distribution of Students' Creative Thinking Scores

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Scores	Question Number			
	1	2	3	4
4	3	0	8	1
3	11	6	8	9
2	5	15	5	9
1	8	6	6	8
0	2	2	2	2

Table 2 illustrates the distribution of students' scores across the four test items. The distribution reveals that only a small proportion of students achieved the maximum score on any given item, while the majority obtained partial scores. Notably, no student achieved a perfect score on Item 2, which corresponds to the flexibility indicator. This finding reinforces the indication that flexibility represents the most challenging dimension of creative thinking for students in this study.

The score distribution also reflects considerable variability in students' responses, suggesting differences in prior knowledge, spatial reasoning ability, and capacity to critically engage with ChatGPT-generated information. Students who achieved higher scores generally demonstrated greater independence in verifying AI-generated solutions, whereas lower-scoring students tended to reproduce ChatGPT responses without sufficient modification or validation.

Table 3.
Mean Scores by Creative Thinking Indicator

No	Mathematical Creative Thinking Indicators	Maximum Score	Skor	
			$\bar{x}$	%
1	The ability to generate more than one valid solution or response to a given problem. (*fluency*).	4	2,17	54%
2	The ability to employ a variety of strategies or approaches in solving a given problem (*flexibility*).	4	1,86	47%
3	he ability to produce uncommon, novel, or unconventional solutions (*Originality*).	4	1,97	49%
4	The ability to develop ideas, objects, or situations in detail by providing clear, complete, and well-structured explanations (*Elaboration*).	4	2,48	62%

Table 3 summarizes students' mean scores for each indicator of mathematical creative thinking. The elaboration indicator yielded the highest average score (2.48 or 62%), indicating that students were relatively proficient in providing detailed explanations and coherent reasoning. This result suggests that ChatGPT effectively supported students in structuring their written responses and articulating solution steps, thereby enhancing the clarity and completeness of their explanations.

Conversely, the flexibility indicator recorded the lowest mean score (1.86 or 47%), followed by originality (1.97 or 49%). These findings indicate that students experienced difficulties in generating varied strategies and producing novel solutions. The limited performance in originality suggests that students often adhered closely to conventional or AI-

generated solutions rather than transforming them creatively. This pattern implies that while ChatGPT may facilitate elaboration, it does not inherently promote divergent thinking unless students possess sufficient conceptual understanding and metacognitive awareness.

B. Descriptive Qualititative

The qualitative data provide a detailed portrayal of students' reasoning patterns and creative responses observed during ChatGPT-assisted geometry learning.

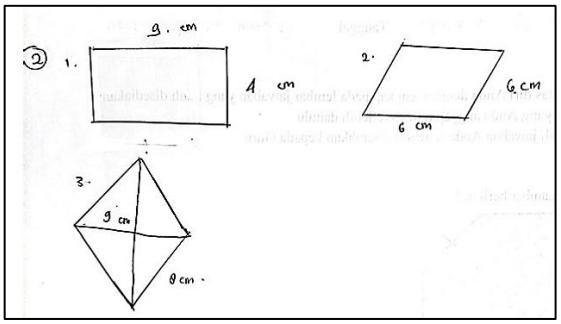

Figure 1. Students' Responses on the Flexibility Aspect.

Figure 1 presents a representative student response related to the flexibility aspect of mathematical creative thinking in geometry problem solving. The student attempted to solve the problem using a single dominant strategy and did not demonstrate alternative solution paths or varied representations. Although the response reflects an understanding of the basic geometric concept, the solution process shows limited strategic variation, indicating that the student relied on a familiar approach rather than exploring multiple possible methods.

Further qualitative analysis reveals that the student's solution closely followed the procedural structure suggested by ChatGPT, with minimal modification or independent exploration. This pattern suggests that while ChatGPT supported the organization of solution steps, it did not effectively stimulate strategic diversity. Consequently, the student's flexibility remained constrained, particularly in tasks requiring the consideration of alternative geometric relationships. These findings indicate that flexibility in mathematical creative thinking does not emerge automatically through AI assistance and requires deliberate instructional scaffolding to encourage the exploration and comparison of multiple strategies.

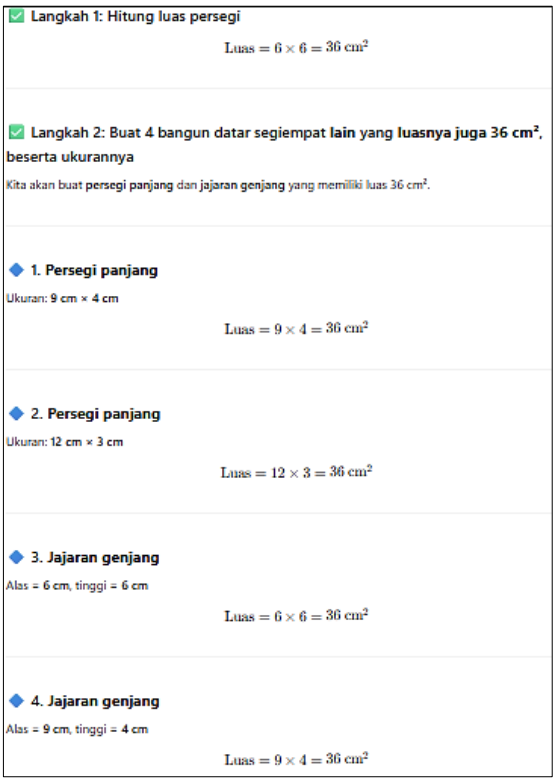

Figure 2. ChatGPT's Response on the Flexibility Aspect.

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Figure 2 presents the solution generated by ChatGPT for the same flexibility-related task. The response demonstrates a structured and sequential explanation, outlining multiple procedural steps that could potentially be interpreted as different approaches. However, the solution lacks explicit geometric sketches or visual representations, which are essential in geometry problem solving. Although ChatGPT provides alternative reasoning pathways in textual form, the absence of visual support may reduce its effectiveness in fostering genuine strategic flexibility among students. This result indicates that while ChatGPT can suggest varied procedural perspectives, these do not always translate into meaningful strategic diversity in students' solutions.

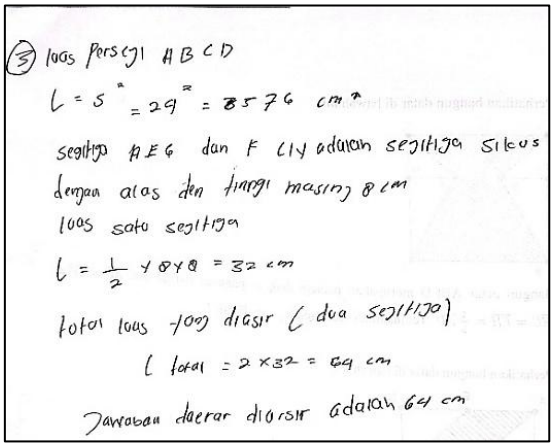

Figure 3. Students' Responses on the Originality Aspect.

Figure 3 depicts a student's response addressing the originality indicator. The solution shows that the student largely followed conventional procedures commonly used in geometry problem solving, with minimal evidence of novel or uncommon reasoning. Although the student attempted to adapt the solution to the given problem, the approach closely resembled standard methods and did not introduce innovative geometric constructions or unique perspectives. This finding suggests that the student struggled to move beyond routine strategies, indicating limited originality in mathematical thinking, even when supported by ChatGPT.

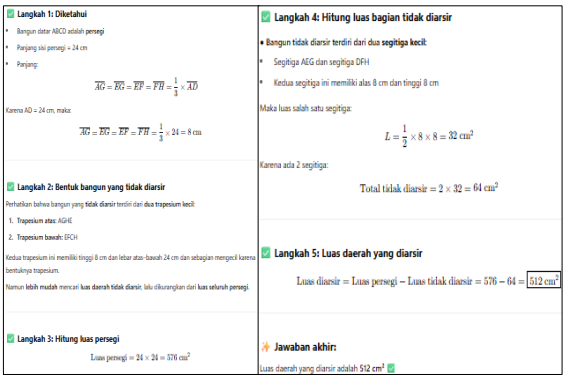

Figure 4. ChatGPT's Response on the Originality Aspect.

Figure 4 shows ChatGPT's response to a geometry problem designed to assess originality. While the solution appears coherent and convincing in its step-by-step reasoning, it contains conceptual inaccuracies related to geometric interpretation. Specifically, the response applies a generalized assumption that does not fully align with the geometric constraints of the problem. This result highlights that ChatGPT-generated solutions may appear logically sound yet lack conceptual precision, particularly in tasks requiring spatial reasoning and diagram interpretation. Such

characteristics may mislead students if the solution is adopted uncritically, thereby limiting opportunities for creative transformation and original reasoning

Table 4.
Comparison of ChatGPT-Generated and Students' Responses in Geometry Problem Solving

Aspect	ChatGPT Responses	Students' Responses
Fluency	ChatGPT generally provides a clear and structured interpretation of the problem based on textual information; however, it may overlook implicit geometric constraints or visual cues.	Students' interpretations vary; some correctly identify key conditions, while others misinterpret geometric relationships, especially when relying heavily on ChatGPT's explanation.
Flexibility	ChatGPT typically applies a single dominant procedural strategy presented in a sequential manner, which emphasizes efficiency and logical flow.	Most students tend to adopt the same strategy suggested by ChatGPT, with limited exploration of alternative approaches, indicating restricted flexibility in strategy selection.
Originality	The solutions generated by ChatGPT are generally conventional and based on standard geometric procedures rather than novel constructions.	Students' solutions show low originality, as many closely replicate ChatGPT's structure and reasoning, with minimal creative transformation or personal adaptation.
Elaboration	ChatGPT provides detailed, step-by-step explanations that clearly articulate the reasoning process, even when the underlying concept is not fully accurate.	Students benefit from ChatGPT's structured explanations, resulting in more detailed and coherent written solutions, particularly in the elaboration aspect.
Accuracy of Concepts	While ChatGPT's responses appear logically convincing, some contain conceptual inaccuracies, particularly in tasks requiring spatial visualization or diagram interpretation.	Some students are able to identify and correct these inaccuracies, but many reproduce the errors without critical evaluation, reflecting varying levels of conceptual understanding.
Critical Engagement	ChatGPT does not evaluate or verify its own solutions unless explicitly prompted.	Students demonstrate heterogeneous engagement: some critically assess ChatGPT's output, while others accept it uncritically as an authoritative answer.

Table 4 presents a qualitative comparison between ChatGPT-generated responses and students' responses in geometry problem solving. The analysis shows that ChatGPT consistently produces well-organized and sequential solutions that support clarity and detailed explanation, thereby contributing positively to the elaboration aspect of mathematical creative thinking. However, these solutions tend to rely on a single dominant procedural strategy and are largely conventional, offering limited novelty and strategic variation. In contrast, students' responses exhibit greater variability; many students adopt the structure and reasoning provided by ChatGPT, which enhances the completeness of their explanations but simultaneously constrains flexibility and

originality. Importantly, the table also reveals differences in students' critical engagement with AI-generated outputs: while some students are able to identify and correct conceptual inaccuracies in ChatGPT's responses, others reproduce the AI-provided solutions without sufficient verification. These findings indicate that ChatGPT primarily functions as a procedural and elaborative scaffold in geometry learning, and its effectiveness in supporting mathematical creative thinking depends strongly on students' ability to engage critically and reflectively with AI-generated information.

C. Discussion

The findings of this study provide nuanced insights into the role of ChatGPT in supporting students' mathematical creative thinking in geometry learning. Overall, the results indicate that students demonstrated a moderate level of mathematical creative thinking when engaging with geometry tasks assisted by ChatGPT, with notable variation across the four creative thinking indicators. This pattern suggests that while ChatGPT can function as a supportive cognitive tool, its impact on creative thinking is selective and highly dependent on the nature of the task and the students' underlying conceptual understanding.

One of the most salient findings is that the elaboration indicator achieved the highest level of performance among students. This result aligns with prior research indicating that generative AI tools are particularly effective in supporting procedural clarity, structured explanations, and the articulation of reasoning steps (Al-Emran, 2024; Baidoo-Anu & Owusu Ansah, 2023). ChatGPT's ability to generate coherent, step-by-step responses appears to have facilitated students' capacity to elaborate their solutions in detail, even when their conceptual understanding was still developing. From a cognitive scaffolding perspective, this finding supports the notion that AI-based tools can reduce extraneous cognitive load by organizing information and guiding learners through solution processes, thereby allowing them to focus on expressing their reasoning more clearly (Redifer et al., 2021).

In contrast, students' performance on the flexibility and originality indicators was comparatively low. These indicators are closely associated with divergent thinking, which requires learners to generate multiple strategies, consider alternative perspectives, and construct novel solutions. The limited development of flexibility observed in this study suggests that students tended to rely on a single solution pathway, often derived directly from ChatGPT's responses. This finding resonates with concerns raised in the literature that overreliance on AI-generated outputs may constrain strategic exploration and inhibit the development of independent problem-solving skills (Alvarez, 2024; Kaitharath et al., 2024).

Rather than prompting students to explore multiple approaches, ChatGPT may inadvertently reinforce convergent thinking when its responses are treated as authoritative or definitive.

Similarly, the relatively low performance on originality indicates that students struggled to transform AI-generated information into genuinely novel mathematical ideas. Although ChatGPT occasionally provided alternative explanations, students rarely extended or restructured these ideas creatively. This result is consistent with previous studies reporting mixed effects of ChatGPT on creativity, where some learners benefit from exposure to diverse ideas while others demonstrate reduced originality due to imitation or surface-level adoption of AI outputs (Habib et al., 2024; Toma & Yánez-Pérez, 2024). In geometry learning, where visualization and spatial reasoning play a central role, this challenge may be further exacerbated by the limitations of text-based AI systems in accurately representing and interpreting geometric diagrams.

While ChatGPT appeared to support comprehension of problem statements, it was less effective in ensuring accurate conceptual application, particularly in visually complex geometry tasks. This finding corroborates earlier research highlighting that AI-generated solutions may appear mathematically plausible while containing subtle conceptual inaccuracies, especially in tasks requiring spatial interpretation (Arista et al., 2023; Mohammad et al., 2023).

Importantly, the qualitative comparison between ChatGPT-generated solutions and students' responses revealed heterogeneous patterns of engagement. Some students demonstrated reflective use of ChatGPT by critically evaluating its responses, identifying errors, and refining solutions accordingly. These students exhibited stronger indicators of creative thinking and greater metacognitive awareness. In contrast, other students reproduced ChatGPT's solutions with minimal scrutiny, including instances where the AI output was incomplete or incorrect. This divergence underscores the importance of learners' prior knowledge, self-regulation, and critical disposition in mediating the effectiveness of AI-assisted learning (Groeneveld et al., 2023; Suherman & Vidákovich, 2024)

Taken together, these findings highlight that ChatGPT is more effective as a tool for supporting elaborative and procedural aspects of mathematical problem solving than for fostering higher-level divergent thinking skills such as flexibility and originality. From a pedagogical standpoint, this suggests that the integration of ChatGPT into geometry instruction should be carefully structured to promote critical engagement rather than passive consumption. Teachers play a crucial role in designing tasks that encourage students to question, compare, and extend AI-generated solutions, thereby transforming

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ChatGPT from a source of answers into a catalyst for creative exploration (Canonigo, 2024; Rospigliosi, 2023).

This study contributes to the growing body of literature on artificial intelligence in mathematics education by providing empirical evidence from a secondary school geometry context. Unlike many prior studies that focus on higher education or general learning outcomes, this research illuminates how ChatGPT interacts with specific dimensions of mathematical creative thinking and reveals both its pedagogical affordances and limitations. These insights underscore the need for a balanced human–AI collaboration framework in which generative AI supports, rather than supplants, students' independent reasoning and creative development.

IV. CONCLUSION

This study concludes that ChatGPT-assisted learning plays a nuanced and selective role in supporting students' mathematical creative thinking in geometry. The findings indicate that seventh-grade students demonstrated a moderate level of creative thinking, with ChatGPT providing the strongest support in the elaboration dimension by helping students articulate solution steps in a more structured and coherent manner. In contrast, the dimensions of flexibility and originality remained comparatively weak, suggesting that while ChatGPT functions effectively as a procedural and elaborative scaffold, it does not inherently foster divergent thinking or strategic variability in geometry problem solving. These results should be interpreted with caution, as the findings are specific to Grade 7 students, who may be more vulnerable to mimicking AI-generated solutions than older learners or university students with more developed metacognitive and conceptual skills. The study also acknowledges its limitations, including the relatively small sample size, the short duration of the intervention, and the focus on a single school context, which restrict the generalizability of the findings. Future research is therefore recommended to employ longitudinal designs to examine the long-term impact of AI-assisted learning on creative thinking development, as well as comparative studies across different educational levels to explore age-related differences in students' interactions with generative AI. From a pedagogical perspective, teachers are encouraged to integrate ChatGPT in a guided and reflective manner by designing tasks that require students to compare multiple strategies, justify their reasoning, and critically evaluate AI-generated responses, thereby transforming ChatGPT from a source of ready-made solutions into a tool that supports creative autonomy and conceptual understanding.

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