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Enhancing Mathematical Achievement through the Think-Pair-Share Cooperative Learning Model with Higher-Order Thinking Skills Questions

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ABSTRACT

This study aims to investigate the effectiveness of the Think-Pair-Share (TPS) cooperative learning model, enhanced with Higher-Order Thinking Skills (HOTS) questions, in improving students' mathematical achievements, particularly in congruence and similarity topics. Conducted as an experimental study in Junior High School 1 Ampana Tete, the study involved 56 ninth-grade students divided into an experimental group (TPS with HOTS questions) and a control group (conventional teaching). The research instruments comprised pretest and posttest achievement tests specifically designed to measure students' understanding and were validated for content with a Cronbach's alpha reliability of 0.65, ensuring accuracy and consistency in measurement. Statistical analyses revealed that the experimental group demonstrated significant improvement in posttest scores (mean score of 59.07) compared to the control group (mean score of 40.86), with an N-Gain of 0.517, indicating a medium level of improvement. This finding underscores the potential of the TPS model with HOTS questions to create an engaging, intellectually stimulating learning environment that enhances students' mathematical performance. These insights support the integration of TPS and HOTS into teaching practices to foster higher-order cognitive skills in mathematics.

Penelitian ini bertujuan untuk mengkaji efektivitas model pembelajaran kooperatif Think-Pair-Share (TPS) yang dipadukan dengan pertanyaan Higher-Order Thinking Skills (HOTS) dalam meningkatkan prestasi matematika siswa, khususnya pada topik kongruensi dan kesebangunan. Penelitian eksperimen ini dilaksanakan di SMP Negeri 1 Ampana Tete dengan melibatkan 56 siswa kelas IX yang terbagi menjadi kelompok eksperimen (TPS dengan pertanyaan HOTS) dan kelompok kontrol (pembelajaran konvensional). Instrumen penelitian terdiri dari tes pencapaian pretest dan posttest yang dirancang khusus untuk mengukur pemahaman siswa dan telah divalidasi secara isi dengan reliabilitas Cronbach's alpha sebesar 0,65, sehingga memastikan keakuratan dan konsistensi pengukuran. Analisis statistik menunjukkan bahwa kelompok eksperimen mengalami peningkatan signifikan pada skor posttest (rata-rata 59,07) dibandingkan dengan kelompok kontrol (rata-rata 40,86), dengan N-Gain sebesar 0,517 yang menunjukkan tingkat peningkatan sedang. Temuan ini menekankan potensi model TPS dengan pertanyaan HOTS dalam menciptakan lingkungan belajar yang menarik dan merangsang intelektual, yang pada gilirannya meningkatkan prestasi matematika siswa. Hasil ini mendukung integrasi TPS dan HOTS dalam praktik pengajaran untuk mendorong keterampilan kognitif tingkat tinggi pada mata pelajaran matematika.

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INTRODUCTION

The process of learning, particularly in mathematics, involves the structured transfer of knowledge from teachers to students, guided by well-defined instructional goals. Achieving success in this process depends on a range of factors, encompassing teacher-related elements, such as competency and instructional methods, and student-related aspects, such as motivation, prior knowledge, and engagement levels. Effective teaching in mathematics, which is fundamental to developing analytical and critical thinking skills, requires a deep understanding of these factors to create an environment conducive to learning (Gong & Zhou, 2024; Ma et al., 2021; Naziah et al., 2020; Tarlina et al., 2023). Mathematics education is a crucial area of study, as it builds the foundation for problem-solving and logical reasoning skills that are applicable across various academic disciplines and real-life contexts. Teacher competencies, including pedagogical skills and subject-matter expertise, play an essential role in supporting students' academic achievements (Bahmannia et al., 2020; Fajriah et al., 2020; Kostanjevec et al., 2018; Ornopia et al., 2022). Studies show that teachers who engage students actively and use diverse instructional strategies help students attain higher levels of understanding and retention. Effective mathematics teaching thus not only requires proficiency in content but also the ability to engage students through instructional methods that promote active learning and critical thinking (Ornopia et al., 2022). The Think-Pair-Share (TPS) model is one such method that has garnered attention in educational research for its effectiveness in fostering a collaborative and cognitively engaging learning environment.

Collaborative learning models like TPS, grounded in social constructivist theory, emphasize that knowledge is best constructed through social interaction and shared experiences. In the context of mathematics education, where abstract concepts can be challenging for students to grasp, collaborative learning models offer a structured approach for students to discuss, analyze, and make sense of complex ideas through peer interactions (Mundelsee & Jurkowski, 2021; Zuraida & Karyati, 2018). This model enhances student engagement and promotes the exchange of ideas, fostering critical and creative thinking skills that are fundamental to learning mathematics (Rohim & Umam, 2019). While the benefits of TPS in enhancing communication skills and motivation have been established (Raba, 2017), research on its impact on mathematical achievement, particularly in topics like congruence and similarity, is still limited. The Think-Pair-Share model is structured in three phases: Think, where students first contemplate a question or problem individually; Pair, where they discuss their thoughts with a peer, allowing them to refine their ideas and consider alternative perspectives; and Share, where pairs present their ideas to the larger group, facilitating a class-wide exchange of knowledge. This approach fosters a learning environment where students are not only receivers of information but active contributors to the learning process (Rohim & Umam, 2019). This model supports mathematics learning by encouraging students to verbalize their thinking, clarify their reasoning, and collaboratively explore problem-solving strategies.

The TPS model has been shown to positively affect students' achievement, problem-solving, and reasoning abilities, making it a powerful approach in mathematics education (Lumbantoruan & Deliviana, 2023; Majid et al., 2022; Pasandaran et al., 2023). It has also been linked to improvements in critical thinking in various subjects, including mathematics and civics (Marhaeni & Nuryadi, 2022; Srinadi, 2023). Moreover, TPS enhances learning motivation and self-efficacy, which are key to students' educational progress (Adeyinka & Ogunbiyi, 2023; Samaila et al., 2024).

As the demands of the 21st century emphasize the importance of critical thinking, problem-solving, and adaptability, mathematics education has increasingly shifted towards fostering Higher-Order Thinking Skills (HOTS). HOTS in mathematics involve the application of analytical, evaluative, and creative thinking to solve complex problems and navigate unfamiliar situations. Unlike basic recall and comprehension, HOTS require students to make connections between ideas, justify their reasoning, and approach problems from multiple perspectives (Anggraena et al., 2019; Rohim & Umam, 2019). The integration of HOTS into mathematics education is essential, as it enables students to go beyond memorization and algorithmic problem-solving. Students who develop these skills are better equipped to tackle advanced mathematical concepts and apply their knowledge in real-world situations, which is especially valuable in an era defined by rapid technological advancements and complex global challenges (Li & Schoenfeld, 2019). HOTS-aligned instruction promotes active learning, encouraging students to question, analyze, and synthesize information in a manner that cultivates critical thinking and independent learning.

Mathematics is a foundational subject with wide applications, contributing to the development of systematic, creative, and analytical thinking as well as collaborative skills (Sharma, 2021). Mathematics education today emphasizes higher-order thinking skills (HOTS), which involve applying knowledge to complex scenarios (Myelnawan & Setyaningrum, 2021; Rohim & Umam, 2019). As the demands of the 21st century increase, incorporating HOTS in mathematics has become essential for preparing students for various professional fields (Anggraena et al., 2019; Hamdi et al., 2022; Kisa et al., 2020; Li & Schoenfeld, 2019).

Developing cognitive skills, including reasoning, problem-solving, and critical thinking, is central to mathematics education (Manurung et al., 2024). Research supports the TPS model as an effective approach to enhancing these skills by encouraging active participation and fostering problem-solving (Ardiyani et al., 2019). Incorporating HOTS questions within the TPS model represents a promising instructional approach that blends collaborative learning with cognitive rigor. By engaging students in discussions that require higher-order thinking, TPS with HOTS questions challenges students to analyze, evaluate, and synthesize mathematical concepts rather than merely recall procedures (Aizikovitsh-Udi & Cheng, 2015). For example, when students encounter a HOTS question on congruence and similarity, they must not only recognize the properties of geometric shapes but also justify their reasoning, explore multiple solutions, and communicate their findings to peers.

Traditional lecture-based instruction remains prevalent in mathematics classrooms but often falls short in promoting critical thinking and engagement (Khasawneh et al., 2023). This approach, which typically involves one-way communication from teacher to student, emphasizes rote memorization and procedural learning. While traditional methods can be effective for introducing foundational knowledge, they may not provide the interactive and reflective experiences needed for students to fully grasp and apply complex mathematical concepts (Lee & Paul, 2023; Lessani et al., 2017). Studies comparing traditional methods with interactive learning models consistently show that students in traditional classrooms tend to achieve lower levels of problem-solving ability and critical thinking. For instance, Lessani et al. (2017) found that cooperative learning models, including TPS, fostered significantly better outcomes in students' problem-solving skills than did traditional methods. The passive nature of lecture-based instruction may disengage students, limiting their opportunities for cognitive growth and interaction with the material. Consequently, many educators are shifting towards more interactive models like TPS to foster a deeper understanding of mathematics and prepare students for higher-order cognitive tasks.

Despite the growing body of research supporting collaborative and inquiry-based methods, there is limited empirical evidence on the specific impact of combining TPS with HOTS questions in mathematics education. Most existing studies on TPS focus on its general effects on student engagement and performance across various subjects, but few have examined its potential to improve mathematical achievement when paired with HOTS. This study aims to address this gap by investigating the effectiveness of TPS with HOTS questions on students' mathematical achievement, specifically focusing on the topics of congruence and similarity in a ninth-grade classroom setting. This study addresses this gap by examining the influence of the TPS model, integrated with HOTS questions, on Grade IX students' achievement in these topics at Junior High School 1 Ampana Tete.

This study holds significant implications for mathematics education, as it explores an instructional model that aligns with modern educational goals of fostering critical thinking, creativity, and

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adaptability (Ardiyani et al., 2019). By integrating TPS with HOTS questions, educators can create a learning environment that not only supports content mastery but also prepares students for complex, real-world challenges (Bamiro, 2015; Sa'dijah et al., 2021). Furthermore, the study's focus on congruence and similarity, topics that often require abstract thinking, highlights the potential of TPS with HOTS questions to address specific learning difficulties in mathematics. This study contributes to the field of education by demonstrating the value of combining collaborative and cognitive strategies to enhance academic outcomes. As educational systems worldwide continue to adapt to the demands of the 21st century, approaches like TPS with HOTS questions offer a promising path forward for developing students' analytical and problem-solving capabilities.

METHOD

This study employed a quasi-experimental design with a pretest-posttest control group (Creswell & Creswell, 2023) (Table 1) to evaluate the impact of the Think-Pair-Share (TPS) model combined with Higher-Order Thinking Skills (HOTS) questions on students' mathematical achievements in the topics of congruence and similarity.

Table 1. The design of Pretest-Posttest control group

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_1	-	O_2

The participants were 56 ninth-grade students from Junior High School 1 Ampana Tete, selected through stratified random sampling. The sample was divided into two equal groups: the experimental group (Class IX A), which received instruction using the TPS model integrated with HOTS questions, and the control group (Class IX B), which followed conventional teaching methods. Each group consisted of 28 students.

The experimental group received instruction using the TPS model, which included three structured phases: Think, Pair, and Share. In the "Think" phase, students individually considered a set of HOTS questions related to congruence and similarity, stimulating critical thinking. During the "Pair" phase, students discussed their answers with a partner, comparing solutions and collaborating on approaches. Finally, in the "Share" phase, pairs presented their findings to the entire class, with the teacher facilitating discussions to ensure comprehensive understanding of key concepts. The control group followed a traditional lecture-based approach, focusing on the same topics without the structured interaction and HOTS questioning.

To measure students' understanding and performance, pretests and posttests were administered. Each test comprised 20 multiple-choice questions and five short-answer questions aligned with curriculum standards. These questions were reviewed by subject matter experts to ensure content validity. A pilot study confirmed the reliability of the test instruments, yielding a Cronbach's alpha value of 0.65, indicating acceptable reliability.

Data were collected in two stages, initially through the administration of the pretest to both the experimental and control groups to establish baseline knowledge, followed by the posttest after the intervention to assess the impact of the TPS model with HOTS questions. The data were examined through the application of both descriptive and inferential statistical analyses. Descriptive statistics provided a summary of the implementation and outcomes of the TPS model, such as mean, standard deviation, frequency, percentage, and n-gain (Hake, 1998), while inferential statistics, such as t-test (Gravetter et al., 2021), was employed to compare the pretest and posttest scores between the two groups.

RESULT

The examination of pretest and posttest data demonstrates a notable enhancement in the mathematical achievement of the experimental group after the integration of the Think-Pair-Share (TPS) approach in conjunction with Higher-Order Thinking Skills (HOTS) inquiries. The descriptive statistics, presented in Table 2, show that the mean posttest score of the experimental group increased from 16.36

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(SD = 7.91) to 59.07 (SD = 14.33), whereas the control group's mean score increased from 15.89 (SD = 7.14) to 40.86 (SD = 18.74).

Table 2. Pretest and posttest scores for experimental and control groups

Group	Test	Minimum	Maximum	Mean	Std. Deviation
Experimental	Pretest	2	35	16.36	7.91
	Posttest	35	82	59.07	14.33
Control	Pretest	4	31	15.89	7.14
	Posttest	10	78	40.86	18.74

The distribution of posttest scores, detailed in Table 3, indicates that 14.29% of students in the experimental group achieved scores in the "High" category (80-89), and 17.86% fell into the "Medium" category (65-79). In contrast, the control group had only 10.71% of students in the "Medium" category, with a majority of 78.58% in the "Very Low" category (0-54).

Table 3. Distribution of Posttest Scores

Score Range	Category	Frequency (Experimental)	Percentage (Experimental)	Frequency (Control)	Percentage (Control)
90 - 100	Very High	0	0%	0	0%
80 - 89	High	4	14.29%	0	0%
65 - 79	Medium	5	17.86%	3	10.71%
55 - 64	Low	7	25.00%	3	10.71%
0 - 54	Very Low	12	42.86%	22	78.58%

To additionally measure the enhancements, the normalized gain (N-Gain) was computed, as illustrated in Table 4. The experimental cohort achieved an N-Gain value of 0.517, implying a moderate degree of progress, while the control group demonstrated an N-Gain of 0.303, indicating a lower level of improvement.

Table 4. Normalized Gain (N-Gain)

Group	N-Gain	Category
Experimental	0.517	Medium
Control	0.303	Low

The results of the independent samples t-test (Table 5) suggest a notable disparity in posttest outcomes between the experimental and control cohorts, with statistical significance ($p < 0.05$). This outcome suggests that the TPS model, when paired with HOTS questions, significantly enhances students' mathematical achievements compared to traditional teaching methods.

Table 5. Results of Independent Samples T-Test

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
Equal variances	4.085	54	0.000	18.214	4.459	9.275 to 27.154
not assumed	4.085	50.529	0.000	18.214	4.459	9.260 to 27.168

DISCUSSION

This study investigated the impact of the Think-Pair-Share (TPS) cooperative learning model combined with Higher-Order Thinking Skills (HOTS) questions on ninth-grade students' achievement in mathematical topics of congruence and similarity. The results showed that the TPS model, when integrated with HOTS questions, had a positive impact on students' mathematical performance. This finding aligns with and expands on existing literature, supporting the notion that collaborative learning frameworks coupled with cognitive engagement strategies can significantly enhance learning outcomes in mathematics.

Effectiveness of the TPS Model with HOTS Questions

The posttest results indicate a substantial improvement in the experimental group's scores, with a mean posttest score of 59.07 compared to 40.86 in the control group. This difference is statistically significant, suggesting that the TPS model, enriched with HOTS questions, effectively fosters a deeper level of cognitive engagement than traditional teaching methods. The experimental group's N-Gain

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score of 0.517, categorized as moderate, further reflects the model's efficacy in enhancing students' academic progress, while the control group's lower N-Gain of 0.303 indicates limited improvement under conventional instruction. The TPS model has demonstrated substantial benefits for student mathematical achievement across various educational settings. In this study, students who engaged with the TPS model and HOTS questions achieved higher posttest scores compared to those in the control group, suggesting the TPS model's effectiveness in promoting sustained academic gains.

These findings align with previous studies on the TPS model's impact in fostering student engagement and collaborative problem-solving. For example, Adeyinka and Ogunbiyi (2023) found that the TPS model significantly boosted students' achievement in geography, suggesting that the structured phases of individual thinking, paired discussion, and whole-class sharing help students consolidate their understanding. The current study adds to this body of work by demonstrating similar benefits in a mathematics context, emphasizing that the integration of HOTS questions can push students to analyze, evaluate, and synthesize mathematical concepts rather than simply memorizing procedures (Samaila et al., 2024).

Previous study by Pramasanti (2024) also reported that the TPS model led to a significant increase in student mathematics learning outcomes, with average scores rising from 71.76 to 80.00 over two cycles and learning completeness improving from 61.76% to 88.24%. Additionally, study by Raba (2017) indicated that TPS enhances oral communication skills in English as a Foreign Language (EFL) classrooms, which can translate into better articulation of mathematical reasoning in this study. By integrating HOTS questions, this study expands Raba's findings by showing that the TPS model can promote higher-order cognitive skills that are essential in mathematics. Specifically, HOTS questions require students to apply concepts to new and abstract scenarios, challenging them to think critically and reason deeply, which may lead to sustained learning gains. Such findings support the notion that TPS fosters an interactive and reflective environment that strengthens students' understanding of complex mathematical concepts, allowing them to reach higher levels of mastery.

The integration of HOTS questions within the TPS framework encourages students to engage in higher-level cognitive processes, such as analysis, evaluation, and synthesis, which are essential for tackling complex mathematical problems. Research by Sulistyawati et al. (2023) and Nurwulandari and Rofiq (2021) highlights that HOTS questions prompt students to move beyond rote memorization, requiring them to deconstruct problems, evaluate potential solutions, and synthesize concepts to arrive at answers. In this study, the experimental group's ability to achieve a higher mean posttest score than the control group can be attributed to the cognitive demands of HOTS questions, which not only enhanced their critical thinking but also cultivated their problem-solving abilities. These skills are crucial in mathematics, where students must frequently analyze multifaceted problems and apply theoretical concepts to real-world scenarios.

Despite the evident benefits, it is crucial to recognize that the effectiveness of the TPS model with HOTS questions may vary depending on the subject matter, student readiness, and teacher facilitation skills. Triyono et al. (2024) reported that the TPS model was less effective in enhancing geometry learning outcomes, suggesting that certain mathematical topics may not lend themselves as readily to the TPS framework. Additionally, the success of TPS depends on the teacher's ability to effectively manage and guide discussions, as well as on students' initial abilities to engage with HOTS questions. Therefore, educators should carefully consider these factors when implementing TPS with HOTS questions, tailoring the approach to fit the specific educational context and learning objectives.

Comparison with Traditional Teaching Methods

The findings from this study reveal a significant gap in posttest performance between the experimental group, which used the Think-Pair-Share (TPS) model with Higher-Order Thinking Skills (HOTS) questions, and the control group, which followed traditional lecture-based instruction. This disparity highlights the limitations of conventional teaching approaches in cultivating essential skills such as critical thinking, problem-solving, and engagement, which are particularly crucial in mathematics education. Traditional methods, while effective for delivering foundational content, often lack the interactive and dynamic components needed to foster deep understanding and independent reasoning. In contrast, active learning strategies, such as TPS, demonstrate considerable potential for enhancing students' academic performance by promoting critical engagement and cognitive development.

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Prior studies have reported similar outcomes when comparing active learning strategies with traditional methods. For instance, Mundelsee and Jurkowski (2021) found that TPS enhances student participation and engagement, leading to improved academic outcomes. The structured "Think-Pair-Share" process encourages individual reflection followed by collaborative discussion, allowing students to build on their initial understanding. This finding resonates with our study's results, as the TPS model allowed students in the experimental group to refine their understanding through peer interactions, leading to stronger performance on the posttest.

Additionally, Ardiyani et al. (2019) observed that students exposed to TPS showed improved mathematical communication and problem-solving skills, particularly in elementary-level mathematics. By applying TPS in a high school context with HOTS questions, this study extends Ardiyani et al.'s work to demonstrate that TPS, combined with cognitive challenge, can also benefit secondary students. The HOTS questions required students to go beyond basic recall, pushing them to use analytical thinking—a skill that traditional methods may not effectively nurture.

Traditional teaching methods, characterized by a focus on direct instruction and memorization, may not cater to diverse learning styles or promote engagement effectively. This lack of interactivity often results in student disengagement and limited development of critical thinking skills (Lee & Paul, 2023). Studies by Lessani et al., (2017) confirm that traditional methods are less effective in fostering problem-solving skills and overall mathematical proficiency compared to interactive, student-centered approaches. In this study, the control group receiving traditional instruction exhibited only modest improvements in posttest scores, which highlights the constraints of traditional methods in addressing complex cognitive tasks.

Traditional instruction can still play a valuable role in introducing foundational concepts and procedures. However, when applied as the primary teaching strategy, it may fail to cultivate the critical thinking and analytical skills that are essential for higher-level mathematics. By focusing on rote memorization and one-way knowledge transmission, traditional approaches may limit students' ability to transfer their knowledge to new contexts and solve real-world problems. Consequently, traditional methods may need to be supplemented with more interactive, student-centered approaches, such as TPS, to fully engage students in mathematical learning.

Although interactive models like TPS offer significant advantages, traditional teaching methods still have an important role in providing structure and foundational knowledge in mathematics education. While constructivist and cooperative approaches are more effective for fostering higher-order thinking, traditional instruction can serve as a basis for introducing new material in a clear, structured manner. A balanced approach that incorporates elements of both traditional and innovative methods may better accommodate diverse student needs and learning styles, offering foundational knowledge through direct instruction while encouraging deeper engagement through interactive, student-centered activities.

For optimal effectiveness, teachers may use traditional methods to introduce basic concepts and then transition to interactive strategies like TPS for in-depth exploration and application. This combined approach can create a comprehensive learning environment that promotes both foundational understanding and cognitive engagement. Ultimately, this balance may help address the limitations of traditional instruction while maximizing the benefits of cooperative and constructivist learning models, thus better preparing students for success in mathematics.

Implications for Teaching Practice

These findings have significant implications for teaching practices in mathematics, as they highlight the benefits of incorporating both collaborative and cognitive strategies in instructional models. The TPS model with HOTS questions encourages students to actively engage in the learning process, fostering both individual accountability and collective understanding. This collaborative model promotes essential cognitive skills such as critical thinking, logical reasoning, and problem-solving, which are foundational for success in mathematics and other analytical disciplines (Aizikovitsh-Udi & Cheng, 2015; Sharma, 2021).

Collaborative learning models like TPS have been shown to improve mathematical understanding and reasoning. Studies indicate that students engaged in these interactive learning activities demonstrate superior mathematical abstraction and reasoning abilities compared to those in traditional learning settings (Deny Hadi Siswanto & Susetyawati, 2024; Majid et al., 2022). By working in pairs and groups,

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students can explore mathematical concepts from different perspectives, facilitating a more comprehensive understanding of abstract ideas.

In addition to enhancing conceptual understanding, the integration of HOTS questions within TPS encourages students to engage in complex cognitive processes, fostering skills in critical thinking and analytical reasoning. This aligns with the goals of inquiry-based learning, which has been shown to stimulate analytical skills and independent thinking (Edwar et al., 2023; Yu et al., 2024). These higher-order thinking processes are crucial for developing students' abilities to tackle challenging problems and make connections between mathematical concepts and real-world applications.

TPS also plays a significant role in improving student engagement and participation. The structured phases of TPS—where students first think individually, then discuss their ideas in pairs, and finally share with the larger group—encourage active involvement and communication. This process not only reinforces understanding but also enhances interpersonal skills as students learn to express, defend, and refine their thoughts through peer interactions (Harianja & Permatasari, 2022; Majid et al., 2022). This level of engagement is often lacking in traditional lecture-based instruction, where students may passively receive information without opportunities for active discussion or questioning.

Educators can benefit from integrating HOTS questions into the TPS model by challenging students to apply their knowledge in diverse and complex scenarios. By doing so, they create a learning environment where students are encouraged to engage deeply with the material, ask questions, and work collaboratively to find solutions. This approach aligns with current educational trends that emphasize active learning, particularly in subjects requiring analytical skills. The TPS model not only encourages interaction but also prepares students to tackle real-world problems by developing a solid foundation in critical thinking and reasoning.

While the benefits of collaborative and cognitive strategies in mathematics education are well-established, their implementation requires careful consideration. Effective execution of TPS with HOTS questions hinges on adequate teacher preparation and training. Teachers must be equipped with the skills to develop and pose HOTS questions, manage collaborative activities, and facilitate meaningful discussions. Workshops and professional development programs that focus on inquiry-based learning and collaborative strategies can be invaluable in preparing teachers for these roles (Edwar et al., 2023). Without such training, teachers may face challenges in sustaining an environment that encourages critical thinking and engagement.

CONCLUSION

This study provides substantial evidence that the Think-Pair-Share (TPS) model, when combined with Higher-Order Thinking Skills (HOTS) questions, significantly enhances students' mathematical achievement, especially in areas such as congruence and similarity. The experimental group demonstrated notable improvements in posttest scores compared to the control group, underscoring the effectiveness of the TPS model in promoting deeper cognitive engagement and active learning. These findings align with prior research, confirming that collaborative and inquiry-based strategies like TPS foster critical thinking, problem-solving, and mathematical reasoning. The integration of HOTS questions within the TPS model created a dynamic learning environment where students actively engaged with complex problems, analyzed solutions, and refined their understanding through peer discussions. This approach supports the development of essential cognitive skills, enabling students to approach mathematical concepts with greater analytical depth and adaptability. The success of TPS with HOTS questions can be attributed to its structured phases of individual reflection, collaborative problem-solving, and group sharing, which collectively promote a thorough and interactive learning process. The implications of this study suggest that educators should consider incorporating TPS and HOTS into mathematics instruction to enhance student engagement and cognitive skills. By leveraging TPS with HOTS questions, teachers can create a stimulating classroom environment that encourages active participation and cultivates a deeper understanding of mathematical principles. However, to maximize the benefits of this approach, it is essential that teachers receive adequate training and resources, particularly in designing and implementing HOTS questions. Despite the promising results, this study has limitations, such as its focus on a single topic and a relatively small sample size, which may affect the generalizability of the findings. Future research should explore the long-term impact of the TPS model with HOTS questions across diverse mathematical topics and among

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broader student populations to validate and expand these results. Additionally, investigating the effectiveness of TPS in different educational contexts would provide further insight into its adaptability and potential for broader application in mathematics education.

REFERENCE

Adeyinka, A. S., & Ogunbiyi, O. M. (2023). A Rural-Urban Comparison of the Effectiveness of Think-Pair-Share (TPS) Strategy of Instruction on Senior Secondary School Students' Academic Achievement in Geography. *CMU Academy Journal of Management and Business Education*, *2*(1), 25–34. https://doi.org/10.53797/cjmbe.v2i1.4.2023

Aizikovitsh-Udi, E., & Cheng, D. (2015). Developing Critical Thinking Skills from Dispositions to Abilities: Mathematics Education from Early Childhood to High School. *Creative Education*, *06*(04), 455–462. https://doi.org/10.4236/ce.2015.64045

Anggraena, Y., Abdulhak, I., & Rusman, R. (2019). The Development of Mathematics Curriculum to Increase the Higher Order Thinking Skills in The 21 st Century Era. *Proceedings of the International Conference of Science and Technology for the Internet of Things*. International Conference of Science and Technology for the Internet of Things, Yogyakarta, Indonesia. https://doi.org/10.4108/eai.19-10-2018.2281302

Ardiyani, S. M., Gunarhadi, G., & Riyadi, R. (2019). The impact of think pair share model on mathematics learning in elementary schools. *Journal of Education and Learning (EduLearn)*, *13*(1), 93–97. https://doi.org/10.11591/edulearn.v13i1.8427

Bahmannia, H., Malaki, H., & Khosravi, M. (2020). Designing a Model for Teacher Competencies in Elementary Education. *Iranian Journal of Educational Sociology*, *3*(3), 123–131. https://doi.org/10.52547/ijes.3.3.123

Bamiro, A. O. (2015). Effects of Guided Discovery and Think-Pair-Share Strategies on Secondary School Students' Achievement in Chemistry. *Sage Open*, *5*(1), 2158244014564754. https://doi.org/10.1177/2158244014564754

Creswell, J. W., & Creswell, J. D. (2023). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (6th ed.). SAGE Publications, Inc.

Deny Hadi Siswanto, & Susetyawati, M. M. E. (2024). Comparison of the Effectiveness of Cooperative Learning Models TPS and GI on Students' Mathematical Concept Understanding Ability. *International Journal of Scientific Multidisciplinary Research*, *2*(7), 875–888. https://doi.org/10.55927/ijsmr.v2i7.10034

Edwar, Putri, R. I. I., Zulkardi, & Darmawijoyo. (2023). Developing a workshop model for high school mathematics teachers in constructing HOTS questions through the Pendidikan Matematika Realistik Indonesia approach. *Journal on Mathematics Education*, *14*(4), 603–626. https://doi.org/10.22342/jme.v14i4.pp603-626

Fajriah, Kahri, M., & Arifin, S. (2020). The Contribution of Pedagogical Competence and Motivation to Get Achievement of the Teachers of Physical Education, Health, and Sports. *Proceedings of the 1st South Borneo International Conference on Sport Science and Education (SBICSSE 2019)*. 1st South Borneo International Conference on Sport Science and Education (SBICSSE 2019), Banjarmasin, Indonesia. https://doi.org/10.2991/assehr.k.200219.037

Gong, L., & Zhou, W. (2024). The Relationship Between Teaching Leadership of College and University Teachers and Academic Achievement of College and University Students: The Mediating Role of Learning Engagement. *The EUrASEANs: Journal on Global Socio-Economic Dynamics*, *1(44)*, 462–471. https://doi.org/10.35678/2539-5645.1(44).2024.462-471

Gravetter, F. J., Wallnau, L. B., Forzano, L.-A. B., & Witnauer, J. E. (2021). *Essentials of statistics for the behavioral sciences* (Edition 10). Cengage.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hamdi, S., Kartowagiran, B., Istiyono, E., & Rahman, H. N. (2022). The ability of Junior High School mathematics teachers writing Higher Order Thinking Skills (HOTS) questions. *Jurnal Riset Pendidikan Matematika*, *9*(2), Article 2. https://doi.org/10.21831/jrpm.v9i2.55191

ISSN 2356-2684 (print), ISSN 2477-1503 (online)

Harianja, R., & Permatasari, C. L. (2022). The Improvement Of Mathematics Learning Outcomes With Think Pair Share Cooperative Learning Model. *JME (Journal of Mathematics Education)*, *7*(2). https://doi.org/10.31327/jme.v7i2.1767

Khasawneh, E., Hodge-Zickerman, A., York, C. S., Smith, T. J., & Mayall, H. (2023). Examining the effect of inquiry-based learning versus traditional lecture-based learning on students' achievement in college algebra. *International Electronic Journal of Mathematics Education*, *18*(1), em0724. https://doi.org/10.29333/iejme/12715

Kisa, S., Ejuu, G., & Asiimwe, J. A. (2020). Teachers' Instructional Practices for Promoting Primary One Learners' Mathematics Competence: A Comparative Study of Busiro and Luuka, Uganda. *American Journal of Education and Practice*, *4*(1), 44–59. https://doi.org/10.47672/ajep.558

Kostanjevec, S., Lovšin Kozina, F., & Erjavšek, M. (2018). The Relationship Between Teachers' Education and Their Self-Perceived Competence for Teaching Home Economics. *Problems of Education in the 21st Century*, *76*(2), 175–188. https://doi.org/10.33225/pec/18.76.175

Lee, J., & Paul, N. (2023). A Review of Pedagogical Approaches for Improved Engagement and Learning Outcomes in Mathematics. *Journal of Student Research*, *12*(3). https://doi.org/10.47611/jsrhs.v12i3.5021

Lessani, A., Suraya Md. Yunus, A., & Abu Bakar, K. (2017). Comparison Of New Mathematics Teaching Methods With Traditional Method. *PEOPLE: International Journal of Social Sciences*, *3*(2), 1285–1297. https://doi.org/10.20319/pijss.2017.32.12851297

Li, Y., & Schoenfeld, A. H. (2019). Problematizing teaching and learning mathematics as "given" in STEM education. *International Journal of STEM Education*, *6*(1), 44, s40594-019-0197–0199. https://doi.org/10.1186/s40594-019-0197-9

Lumbantoruan, J. H., & Deliviana, E. (2023). Development of a logarithmic module equipped with a jigsaw cooperative model. *Jurnal Elemen*, *9*(2), Article 2. https://doi.org/10.29408/jel.v9i2.17520

Ma, X., Fan, C., Nie, Z., & Jia, Y. (2021). Investigation and Countermeasure Research on the Learning Adaptability of the First-Year Junior High Freshman. *Open Journal of Social Sciences*, *09*(08), 70–90. https://doi.org/10.4236/jss.2021.98007

Majid, A. F., Munir, M. M., Mardhiah, Fitriani Nur, & A. Sriyanti. (2022). The Influence Of The Application Of The Think Pair Share (Tps) Cooperative Learning Model On Students' Reasoning Ability And Mathematical Abstract Ability. *MaPan*, *10*(2), 413–427. https://doi.org/10.24252/.2022v10n2a11

Manurung, A. S., Halim, A., & Nur, S. M. (2024). Model of Mathematical Creative Thinking Ability Based on Character Education for Elementary School Students Jakarta. *Asatiza: Jurnal Pendidikan*, *5*(1), 45–60. https://doi.org/10.46963/asatiza.v5i1.1727

Marhaeni, N. H., & Nuryadi, N. (2022). Improving Learning Mathematics Activity With The Think Pair Share Learning Model. *Alifmatika: Jurnal Pendidikan Dan Pembelajaran Matematika*, *4*(1), 52–64. https://doi.org/10.35316/alifmatika.2022.v4i1.52-64

Mundelsee, L., & Jurkowski, S. (2021). Think and pair before share: Effects of collaboration on students' in-class participation. *Learning and Individual Differences*, *88*, 102015. https://doi.org/10.1016/j.lindif.2021.102015

Myelnawan, M., & Setyaningrum, W. (2021). Kemampuan siswa SMP dalam menyelesaikan soal matematika berbasis HOTS. *Jurnal Riset Pendidikan Matematika*, *8*(1), Article 1. https://doi.org/10.21831/jrpm.v8i1.16533

Naziah, R., Caska, C., Nas, S., & Indrawati, H. (2020). The Effects of Contextual Learning and Teacher's Work Spirit on Learning Motivation and Its Impact on Affective Learning Outcomes. *Journal of Educational Sciences*, *4*(1), 30. https://doi.org/10.31258/jes.4.1.p.30-43

Nurwulandari, I., & Rofiq, M. A. (2021). Developing HOTS-based Model to Improve Mathematical Problem Solving Skill of Elementary School Teacher Education (PGSD) Students. *Journal of Physics: Conference Series*, *1842*(1), 012043. https://doi.org/10.1088/1742-6596/1842/1/012043

Ornopia, V. B., Franca, G. C., & Bauyot, M. M. (2022). Instructional Management of School Principals in Implementing New Normal Learning Modality Related to Teachers Competence and school Achievement Goals: Locus of Quality Education amidst COVID-19. *Asian Journal of Education and Social Studies*, 11–24. https://doi.org/10.9734/ajess/2022/v29i230694

ISSN 2356-2684 (print), ISSN 2477-1503 (online)

Pasandaran, S., Pangalila, T., & Mania, T. J. (2023). The Influence of Think Pair Share (TPS) Cooperative Learning Model on Students' Critical Thinking Ability in Civics Learning in XI MIPA Class at SMA Negeri 1 Amurang. In R. Harold Elby Sendouw, T. Pangalila, S. Pasandaran, & V. P. Rantung (Eds.), *Proceedings of the Unima International Conference on Social Sciences and Humanities (UNICSSH 2022)* (Vol. 698, pp. 1739–1746). Atlantis Press SARL. https://doi.org/10.2991/978-2-494069-35-0_206

Pramasanti, D. K. (2024). Penerapan Model Pembelajaran Kooperatif Tipe Think-Pair-Share (TPS) Untuk Meningkatkan Hasil Belajar Matematika Siswa. *Metta : Jurnal Ilmu Multidisiplin*, *4*(1), 12–23. https://doi.org/10.37329/metta.v4i1.2832

Raba, A. A. A. (2017). The Influence of Think-Pair-Share (TPS) on Improving Students' Oral Communication Skills in EFL Classrooms. *Creative Education*, *08*(01), 12–23. https://doi.org/10.4236/ce.2017.81002

Rohim, S., & Umam, K. (2019). The Effect of Problem-Posing and Think-Pair-Share Learning Models on Students' Mathematical Problem-Solving Skills and Mathematical Communication Skills. *JETL (Journal Of Education, Teaching and Learning)*, *4*(2), 287. https://doi.org/10.26737/jetl.v4i2.803

Sa'dijah, C., Murtafiah, W., Anwar, L., Nurhakiki, R., & Cahyowati, E. T. D. (2021). Teaching Higher Order Thinking Skills In Mathematics Classrooms: Gender Differences. *Journal on Mathematics Education*, *12*(1), 159–180. https://doi.org/10.22342/jme.12.1.13087.159-180

Samaila, K., Tsong, C. K., Masood, M., & Bervell, B. (2024). Think-pair-share based flipped classroom: A model for improving students' learning achievement and self-efficacy. *Journal of Digital Educational Technology*, *4*(1), ep2410. https://doi.org/10.30935/jdet/14422

Sharma, P. (2021). Importance and Application of Mathematics in Everyday Life. *International Journal for Research in Applied Science and Engineering Technology*, *9*(11), 868–879. https://doi.org/10.22214/ijraset.2021.38869

Srinadi, N. P. (2023). Improving Student Learning Outcomes Through the Think Pair and Share Model in Chemistry Learning. *Pinisi Journal of Education and Management*, *2*(2), 117. https://doi.org/10.26858/pjoem.v2i2.51415

Sulistyawati, D., Hadi, W., Hidayat, A., & Muhammad, R. R. (2023). THE IMPACT OF PROBLEM-BASED LEARNING AUGMENTED WITH HOTS PROBLEMS ON STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITIES. *Kalamatika: Jurnal Pendidikan Matematika*, *8*(2), 219–236. https://doi.org/10.22236/KALAMATIKA.vol8no2.2023pp221-238

Tarlina, Cahyadi, A., & Sari, S. (2023). Relationship Between Teacher Competence and Motivation With Student Learning Outcomes in Subjects Elementary School People in Tujuh Belas Sub District. *Kinestetik : Jurnal Ilmiah Pendidikan Jasmani*, *7*(2), 516–525. https://doi.org/10.33369/jk.v7i2.28527

Triyono, A., Nuary, R. H., Permatasari, N., Yuni, Y., & Wibowo, T. (2024). The Level of Effectiveness of TPS and Conventional Methods Judging from Students' Geometry Learning Results Using the N-Gain Test. *AlphaMath : Journal of Mathematics Education*, *10*(1), 125. https://doi.org/10.30595/alphamath.v10i1.21530

Yu, S., Jantharajit, N., & Srikhao, S. (2024). Collaborative inquiry-based instructional model to enhance mathematical analytical thinking and reasoning skills for fourth-grade students. *Asian Journal of Education and Training*, *10*(1), 10–17. https://doi.org/10.20448/edu.v10i1.5323

Zuraida, D. A., & Karyati, K. (2018). The effectiveness comparison problem based learning model with NHT and TPS type on plane solid figure. *Jurnal Riset Pendidikan Matematika*, *5*(2), 254–263. https://doi.org/10.21831/jrpm.v5i2.16444

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