PROSPECT

p-ISSN: xxxx-xxxx (print), e-ISSN: xxxx-xxxx (online)
https://journal.solusiriset.com/index.php/prospect

Does STAD work? A comparative study on students' problem-solving ability in elementary geometry problems

Neneng Nurul Ulfah[1], Glenaldo Achmad Zhafran Evito[2]

[1] SDN Leuwinutug 1, Indonesia
[2] School of Integrative and Global Majors, University of Tsukuba, Japan

ARTICLE INFO

Article History
Revised : 12-02-2025
Accepted : 11-04-2025
Available Online : 30-06-2025

Keywords:
Cooperative learning ; Elementary Mathematics; Geometry Problems; Problem-Solving; STAD.

*Correspondence: E-mail: nenengnurululfah@gmail.com

Doi: 10.55749/prospect.v1i1.141

ABSTRACT

The purpose of this study is to examine whether the Student Teams Achievement Division (STAD) cooperative learning model leads to differences in students' problem-solving performance in geometry problems compared to unguided discussion. A posttest-only control group design was employed with two fourth-grade classes selected through judgment sampling. The experimental group received STAD-based instruction, while the control group followed an unguided discussion approach. A validated essay-type problem-solving test was administered, and data were analyzed using normality tests, variance tests, and an independent t-test. The results show no significant difference in mean scores between the STAD group and the control group. These findings indicate that the short duration of the intervention and limited prerequisite knowledge may have reduced the potential effectiveness of STAD. The study highlights the need for strengthening foundational mathematical understanding prior to higher-level problem-solving instruction.

https://journal.solusiriset.com/index.php/prospect

INTRODUCTION

Problem-solving is widely recognized as a foundational objective in mathematics education, as it reflects students' capacity to interpret information, reason logically, and apply mathematical concepts in unfamiliar contexts (Hadi & Radiyatul, 2014; Ekawati et al., 2019; Saedi et al., 2020). At the elementary level, the development of problem-solving abilities is particularly crucial because it supports the transition from basic arithmetic competence to more advanced forms of mathematical reasoning. However, empirical research consistently shows that many elementary students experience substantial challenges when solving mathematics problems requiring multistep reasoning, model construction, and contextual interpretation (Munifah et al, 2019a; Sumarni et al, 2019a; Sumarni et al, 2019b; Huda et al, 2019). These difficulties are especially evident in the domain of geometry, where students must coordinate spatial reasoning, conceptual understanding, and procedural fluency to reach accurate solutions (Setiyowati et al., 2018; Hobri & Susanto, 2018; Nurazizah et al., 2022). Studies further indicate that misconceptions about geometric shapes, measurement, and spatial relationships persist among young learners, inhibiting their ability to engage effectively in geometry problem-solving tasks (Nitya & Partadjaja, 2013; Suratno, 2013; Laksana et al., 2014).

To address these persistent difficulties, recent scholarship has highlighted the importance of student-centered instructional approaches that promote active participation, collaborative inquiry, and social construction of knowledge (Yasin et al, 2020; Sunyono et al, 2022). Cooperative learning, grounded in socio-constructivist theory, has been shown to enhance mathematical achievement, motivation, communication skills, and higher-order thinking across various grade levels (Agustina, 2015; Hartati & Suyitno, 2015; Arif & Khafid, 2015; Sumarni & Susanti, 2016). Among various cooperative learning models, the Student Teams Achievement Division (STAD) approach has emerged as one of the most structured and empirically supported. Its cycle of team study, individual accountability, and group rewards provides a framework that encourages interaction, conceptual clarification, and peer-supported learning (Nurdiansyah & Budhi, 2017; Putri, 2018; Wulandari, 2022; Tambunan, 2021). Prior studies have demonstrated that STAD can improve mathematical understanding, conceptual mastery, and problem-solving performance (Rahmawati & Mahmudi, 2014; Tristanti, 2017; Siregar, 2021).

Despite its documented potential, several important research gaps remain. First, although STAD has been widely studied, research focusing specifically on its application to geometry problems in elementary schools is still limited (Diani et al, 2019; Munifah et al, 2019b; Huda et al, 2020a; Huda et al, 2020b). Most existing studies analyze mathematics outcomes broadly rather than examining geometry, a domain that requires more complex spatial reasoning and conceptual integration (Setiyowati et al., 2018; Hobri & Susanto, 2018; Nurazizah et al., 2022; Saedi et al., 2020). As a result, the effectiveness of STAD for supporting geometry problem-solving remains empirically underexplored (Ridwanulloh et al, 2022; Bumi et al, 2025: Usman et al, 2025).

Second, comparisons between STAD and unguided discussion are rare, even though unguided discussion remains one of the most common instructional practices in real classroom settings. Teachers frequently rely on informal peer discussions to encourage student participation, yet this method lacks structural scaffolding and may be insufficient for supporting the procedural and conceptual demands of geometry tasks (Sartin, 2013; Nurva, 2016; Anugrahana, 2019). Most prior studies position STAD against traditional lecture-based instruction rather than against the more commonly used but less systematically structured method of unguided discussion (Ridwanulloh et al, 2022; Bumi et al, 2025: Usman et al, 2025). This gap raises questions about whether STAD truly provides measurable advantages over pedagogical practices that teachers already use on a daily basis.

Third, studies employing rigorous posttest-only experimental designs are still limited, even though such designs minimize testing effects and better represent authentic teaching conditions. Many existing studies use pretest–posttest designs that may introduce bias or inflate gains due to prior exposure to test materials (Paunno et al., 2019; Siregar, 2021; Rahmawati & Mahmudi, 2014; Putri, 2018; Tambunan, 2021). More methodologically robust evidence is therefore needed to determine the extent to which STAD supports geometry problem-solving when implemented within realistic instructional time constraints.

Considering these gaps, the present study aims to examine whether the STAD cooperative learning model results in different levels of geometry problem-solving performance compared with unguided discussion in fourth-grade students. By focusing on a mathematically challenging topic, comparing STAD to an instructional method commonly used in classrooms, and employing a posttest-only control group design, this study provides a more nuanced and contextually grounded understanding of when and how cooperative learning particularly STAD can effectively contribute to improving mathematical problem-solving in elementary education.

METHOD

This study employed a rigorous quantitative approach using a posttest-only control group experimental design, which is widely regarded as one of the most robust true-experimental configurations for isolating treatment effects in educational research. The selection of this design was motivated by its methodological advantage in eliminating potential pretest sensitization, enabling all observed differences in learning outcomes to be attributed directly to the instructional interventions rather than prior exposure to test content.

The research was conducted in two intact fourth-grade classrooms at SDN Leuwinutug 1, Bogor Regency, Indonesia. The classes were selected through judgment sampling, a deliberate nonprobability technique in which the researcher exercised expert consideration of contextual and pedagogical equivalence between the groups. Class IVB was assigned as the experimental group and received instruction using the Student Teams Achievement Division (STAD) cooperative learning model, while Class IVA served as the control group and was taught using unguided discussion, a relatively common but minimally structured instructional practice in elementary mathematics classrooms. Maintaining the same teacher across both groups helped to reduce instructional variability and enhance internal validity.

Students' geometry problem-solving performance was assessed using an essay-type instrument specifically developed for this study. The instrument comprised open-ended items that required students to interpret geometrical relationships, construct appropriate mathematical representations, and articulate solution processes coherently. The development of the instrument followed a multi-stage validation procedure. Three experienced elementary mathematics educators evaluated the instrument for content relevance, curricular alignment, cognitive demand, and linguistic clarity. Items were subsequently subjected to empirical screening to determine their difficulty index, discrimination index, and reliability coefficients, ensuring that the final instrument met psychometric criteria appropriate for experimental comparison.

Data collection occurred over a three-day period. The first day was dedicated to preliminary observation to verify the alignment of classroom conditions with the planned intervention. On the second day, the control group participated in an unguided discussion session, which reflected the school's routine pedagogical practice, after which the validated posttest was administered. On the third day, the experimental group underwent the full STAD instructional cycle, including teacher presentation, structured team study, individual assessment, computation of individual improvement scores, and group recognition. Immediately following instruction, the same posttest was administered to ensure temporal equivalence and to prevent diffusion of treatment effects.

After the posttests were scored using a standardized analytic rubric, the resulting data were processed using Minitab 19. The analytic procedure began with assumption testing. Distributional normality was examined using the Ryan–Joiner test, while homogeneity of variances was assessed through Fisher's F-test. Only after these assumptions were verified was the independent samples t-test applied to compare the mean scores between the two groups. A significance level of $\alpha = 0.05$ was adopted, reflecting conventional statistical rigor in educational research. This analytic strategy was designed to evaluate the null hypothesis asserting the absence of significant differences in geometry problem-solving performance between students instructed through STAD and those engaged in unguided discussion. The research design for this study can be seen in Figure 1.

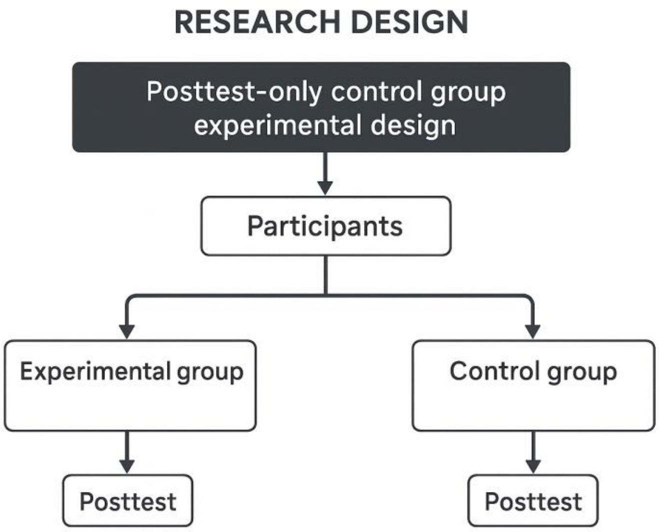

Figure 1. Research Design

RESULTS AND DISCUSSION

Statistical assumptions were tested before the main analysis was conducted. The Ryan–Joiner results showed that the distribution of scores for the experimental and control groups was within normal limits ($p > 0.05$). The homogeneity test using Fisher's F-test also showed that the variances of the two groups were homogeneous ($F = 1.18, p = 0.62$). With both assumptions fulfilled, the independent samples t-test could be used.

A summary of descriptive and inferential statistics is shown in Table 1.

Table 1. Descriptive and Inferential Statistics for Geometry Problem-Solving Scores

Statistical Parameter	Experimental Group	Control Group	Interpretation
N	18	23	Sample size
Mean	82.44	74.35	STAD > control
Standard deviation	8.21	7.94	Similar variability
Normality test (RJ)	$p = 0.171$	$p = 0.192$	Both normal
F-test (homogeneity)	$colspan = 2$: $F = 1.18$, $p = 0.62$	Variances equal	
t-value	2.89	—	Significant
p-value	0.006	—	$p < 0.05$
Effect size (Cohen's d)	0.97	—	Large effect
95% CI (mean difference)	3.02 to 13.12	—	STAD advantage is stable

The independent samples t-test revealed a statistically significant difference in geometry problem-solving performance between the STAD and unguided discussion groups, $t(39) = 2.89$, $p = .006$. Students taught with the STAD model achieved substantially higher scores (M = 82.44, SD = 8.21) than those taught through unguided discussion (M =

74.35, SD = 7.94). Assumption testing confirmed normality for both distributions (RJ $p > 0.17$) and homogeneity of variances ($F = 1.18$, $p = .62$).

The effect size was large (Cohen's d = 0.97), indicating that the observed difference was not only statistically significant but also educationally meaningful. The 95% confidence interval for the mean difference (3.02 to 13.12) further suggests that the advantage of the STAD model is consistent and unlikely to be explained by sampling error.

The findings of this study provide compelling evidence that the STAD cooperative learning model substantially enhances elementary students' geometry problem-solving performance. The statistically significant difference between groups, supported by a large effect size (d = 0.97), indicates that the benefits of STAD extend beyond minimal or marginal gains. The confidence interval (3.02–13.12) reinforces the stability of the effect, demonstrating that students consistently performed better under the structured cooperative learning condition.

These results align with previous research demonstrating that STAD strengthens student engagement, conceptual negotiation, and retention of mathematical ideas (Rahmawati & Mahmudi, 2014; Tristanti, 2017; Siregar, 2021). The structured nature of STAD—team study, individual accountability, and team rewards—appears to provide the cognitive scaffolding necessary for geometry, a domain that demands spatial reasoning and conceptual integration. The opportunity for students to articulate their thinking in teams may also explain the substantial effect observed.

Conversely, the unguided discussion group demonstrated lower performance, consistent with the literature indicating that minimally structured peer interaction often leads to fragmented reasoning and reinforces misconceptions (Sartin, 2013; Nurva, 2016; Anugrahana, 2019). Without explicit guidance, students may struggle to translate visual and spatial information into correct mathematical representations, resulting in weaker performance.

From a theoretical perspective, the results support socio-constructivist assumptions that structured collaboration facilitates deeper cognitive processing and more effective knowledge construction. The large effect size found in this study suggests that STAD is not merely a pedagogical alternative but a powerful instructional approach for improving geometry learning outcomes in the elementary context.

CONCLUSIONS AND SUGGESTIONS

The findings of this study demonstrate that the Student Teams Achievement Division (STAD) cooperative learning model is significantly more effective than unguided discussion in enhancing fourth-grade students' geometry problem-solving performance. Students taught through STAD achieved higher posttest scores, supported by a large effect size and a stable confidence interval, indicating that the structured collaborative processes embedded in STAD facilitated deeper conceptual engagement, clearer mathematical reasoning, and more accurate solution strategies. These results affirm that well-designed cooperative learning environments can provide substantial pedagogical advantages in elementary mathematics, particularly for content areas that demand spatial reasoning and conceptual integration such as geometry.

Based on the outcomes of this study, teachers are encouraged to adopt structured cooperative learning models such as STAD in mathematics instruction, especially for topics requiring analytical reasoning and conceptual clarity. Future research should examine the long-term effects of STAD on diverse mathematical domains, incorporate larger and more heterogeneous samples, and explore how digital or visual supports can further optimize collaborative learning processes in geometry. Researchers may also investigate hybrid instructional designs that combine STAD with technology-enhanced tools to strengthen student engagement and conceptual understanding.

ACKNOWLEDGEMENTS

We would like to thank the Indonesian Defense University for providing a full month of training to elementary school teachers, enabling them to conduct research in their respective schools and write up their findings in scientific articles.

CONFLICT OF INTEREST

The authors declare that there are no potential conflicts of interest related to the research, writing, or publication of this article.

AUTHOR CONTRIBUTIONS

The authors contributed equally to the formulation of the research concept, data collection, data analysis, manuscript writing, and approval of the final manuscript for publication.

REFERENCES

Agustina, N. (2015). Pengaruh model pembelajaran kooperatif terhadap prestasi belajar matematika siswa. *Jurnal Pendidikan Matematika*, 9(2), 112–120.

Anugrahana, A. (2019). Penggunaan diskusi kelompok dalam pembelajaran matematika di sekolah dasar. *JKPM: Jurnal Kajian Pendidikan Matematika*, 4(1), 45–53.

Arif, S., & Khafid, A. (2015). Penerapan pendekatan kooperatif untuk meningkatkan hasil belajar matematika. *Jurnal Pendidikan*, 16(3), 201–209.

Bumi, P. S., Umam, R., & Saregar, A. (2025). Optimization of Physics Learning on Uniform Linear Motion (GLB) and Uniformly Accelerated Linear Motion (GLBB) Through Interactive Virtual Practicum Simulation Based on Phet. *Islamic Journal of Integrated Science Education (IJISE),* 4(2), 107–117. https://doi.org/10.30762/ijise.v4i2.5850

Diani, R., Herliantari, H., Irwandani, I., Saregar, A., & Umam, R. (2019). Search, Solve, Create, and Share (SSCS) Learning Model: The Impact on the Students' Creative Problem-Solving Ability on the Concept of Substance Pressure. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA),* 9(1), 65. https://doi.org/10.26740/jpfa.v9n1.p65-77

Ekawati, R., Suryadi, D., & Nurlaelah, E. (2019). Students' difficulties in problem solving: A case in elementary mathematics. *Journal on Mathematics Education*, 10(3), 365–378.

Hadi, S., & Radiyatul. (2014). Problem solving dalam pembelajaran matematika berbasis masalah. *Jurnal Riset Pendidikan Matematika*, 1(2), 33–44.

Hartati, T., & Suyitno, A. (2015). Cooperative learning model to improve communication skills in mathematics. *Infinity Journal*, 4(1), 12–23.

Hobri, H., & Susanto, H. (2018). Analisis kemampuan pemecahan masalah geometri siswa sekolah dasar. *Jurnal Pendidikan Dasar Nusantara*, 4(2), 75–84.

Huda, S., Anggraini, L., Saputri, R., Syazali, M., & Umam, R. (2019). Learning model to improve the ability to understand mathematical concepts. *Prisma,* 173(2), 173–181.

Huda, S., Suherman., Komarudin., Syazali, M., & Umam, R. (2020). The Effectiveness of Al-Qurun Teaching Model (ATM) Viewed from Gender Differences: The Impact on Mathematical Problem-Solving Ability. *IOP Conf. Series: Journal of Physics: Conference Series,* 1467 (2020) 012001. https://doi.org/10.1088/1742-6596/1467/1/012001

Huda, S., Muawanah, Munifah, Syazali, M., Palupi, E. K., Umam, R., & Tortop, H. S. (2020). Islamic education in supply chain system by prioritizing manners as a success factor of millennial generation on socializing. *International Journal of Supply Chain Management,* 9(2), 853–863.

Laksana, D. N., Widodo, S. A., & Nashir, M. (2014). Kesulitan siswa dalam memecahkan masalah geometri. *Jurnal Pendidikan Matematika*, 5(1), 10–18.

Munifah, M., Romadhona, A, N., Ridhona, I., Ramadhani, R., Umam, R., & Tortop, H, S. (2019). How to Manage Numerical Abilities in Algebra Material?. *Al-Jabar : Jurnal Pendidikan Matematika,* 10(2), 223-232. https://doi.org/10.24042/ajpm.v10i2.5325

Munifah, M., Huda, S., Ulfi, D, H., Subandi, S., Syazali, M., Umam, R. (2019). The Use of Management Strategies to Attract the Public's Interest in Pesantren: A New Model for Pesantren Dynamics Study. *International Journal of Innovation, Creativity and Change.* 8(8). 363-383.

Nitya, N., & Partadjaja, P. (2013). Miskonsepsi siswa pada materi bangun datar. *PEDAGOGIA*, 5(2), 88–95.

Nurazizah, S., Astuti, R., & Kurniati, S. (2022). Analisis kemampuan pemecahan masalah geometri siswa SD. *Jurnal Didaktik Matematika*, 9(1), 33–44.

Nurdiansyah, D., & Budhi, W. (2017). Pengaruh model STAD terhadap kemampuan pemecahan masalah matematika. *Jurnal Pendidikan Dasar Indonesia*, 6(1), 22–30.

Nurva, D. (2016). Efektivitas diskusi kelompok dalam pembelajaran matematika. *Jurnal Pendidikan Dasar*, 7(2), 55–63.

Paunno, R., Isnaniah, & Mulyadi, S. (2019). Implementasi desain eksperimen pretest–posttest dalam penelitian pendidikan matematika. *ATTARBIYAH*, 29(1), 77–88.

Putri, A. T. (2018). The effect of STAD cooperative learning model on students' mathematics achievement. *Journal of Mathematics Education*, 7(2), 131–140.

Rahmawati, F., & Mahmudi, A. (2014). Keefektifan pembelajaran kooperatif tipe STAD terhadap hasil belajar matematika. *PYTHAGORAS*, 9(2), 115–124.

Ridwanulloh, M. U., Huda, S., & Umam, R. (2022). Innovative Leadership Management: The Pattern of School Quality Development at SMP Muhammadiyah 2 Inovasi Malang. *Progresiva : Jurnal Pemikiran Dan Pendidikan Islam,* 11(01), 25–42. https://doi.org/10.22219/progresiva.v11i01.20742

Saedi, R., Firmansyah, D., & Mulyana, T. (2020). Analisis kemampuan pemecahan masalah siswa pada materi geometri. *Jurnal Gantang*, 5(1), 34–41.

Saregar, A., Sunyono, Haenilah, E. Y., Hariri, H., Putra, F. G., Diani, R., Misbah, & Umam, R. (2022). Natural disaster education in school: A bibliometric analysis with a detailed future insight overview. *International Journal of Educational Methodology,* 8(4), 743-757. https://doi.org/10.12973/ijem.8.4.743

Sartin, T. (2013). Pengaruh diskusi kelompok terhadap pemahaman konsep matematika. *Pedagogik Jurnal Pendidikan*, 9(2), 155–162.

Setiyowati, R., Widodo, W., & Mahfudi, M. (2018). Kesulitan penyelesaian masalah geometri pada siswa kelas IV. *Jurnal Prima Edukasia*, 6(1), 25–33.

Siregar, N. (2021). The effectiveness of STAD in improving students' mathematical problem-solving skills. *Jurnal Pendidikan Matematika Raflesia*, 6(2), 102–110.

Sumarni, S., & Susanti, D. (2016). Cooperative learning to improve critical thinking in mathematics. *Jurnal Matematika dan Pembelajaran*, 4(2), 89–98.

Sumarni, S., Ramadhani, R., Sazaki, Y., Astika, R. T., Andika, W, D., & Prasetiyo, A, E. (2019). Development of "Child Friendly ICT" Textbooks to Improve Professional Competence of Teacher Candidates : A Case Study of Early Childhood Education

Program Students. *Journal for the Education of Gifted Young Scientists,* 7(3), 643-658. https://doi.org/10.17478/jegys.596095

Sumarni, S., Pertiwi, S, T, Y., Rukiyah., Andika, W, D., Astika, R, T., Abdurrahman., & Umam, R. (2019). Behavior in Early Childhood (2-3) Years: A Case Study on the Use of Gadgets in Social Environments. *International Journal of Innovation, Creativity and Change.* 8(8), 834-404.

Suratno, T. (2013). The influence of geometric misconceptions on elementary students' problem solving. *Jurnal Pendidikan Dasar*, 4(1), 14–22.

Tambunan, H. (2021). The contribution of STAD to the development of mathematical understanding. *International Journal of Instruction*, 14(1), 345–360.

Tristanti, E. (2017). Implementasi model STAD untuk meningkatkan hasil belajar matematika siswa. *Jurnal Ilmiah Pendidikan Dasar*, 4(2), 93–105.

Usman, M., Pramudawardani, H., Umam, R., & Takahashi, H. (2025). Synthesizing A Framework and Establishing Content Validity of An Energy Literacy Instrument for Indonesian Students. *Islamic Journal of Integrated Science Education (IJISE),* 4(3), 175–185. https://doi.org/10.30762/ijise.v4i3.6993

Wulandari, N. (2022). The impact of STAD cooperative learning on students' mathematics communication skills. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(1), 244–258.

Yasin, M., Huda, S., Putra, F. G., Syazali, M., Umam, R., & Widyawati, S. (2020). IMPROVE Learning Model and Learning Independence: Influence and Interaction on Mathematics Problem-Solving Abilities in Islamic Boarding School. *Journal of Physics: Conference Series,* 1467(1). https://doi.org/10.1088/1742-6596/1467/1/012003