Implementation of the two stay two stray learning model with a realistic mathematics education approach to mathematical understanding ability

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Abstract

This study aims to determine the effectiveness of the Two Stay Two Stray (TS-TS) learning model combined with the Realistic Mathematics Education (RME) approach in improving students' mathematical understanding. The research was conducted at SMPN 1 Sindangagung with eighth-grade students as subjects during the 2023/2024 academic year. Class VIII C was assigned as the experimental group and Class VIII D as the control group was selected using purposive sampling. This study used a quasi-experimental design with a non-equivalent pretest-posttest control group format. The instruments used included an essay test to measure mathematical understanding and teacher interview guidelines during the pre-research phase. Data analysis was carried out using normality and homogeneity tests, N-Gain calculations, and the Mann-Whitney U test. The results indicate a statistically significant difference in improvement between the two classes. Practically, the implementation of the TS-TS model based on RME increased student engagement and conceptual understanding, making it a viable alternative for designing active, collaborative, and meaningful mathematics learning.

Keywords: Cooperative Learning Model, Flat-Sided Geometric Shapes, Mathematical Understanding Ability, Realistic Mathematics Education Approach, Two Stay Two Stray Learning Model.

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INTRODUCTION

Education serves as the fundamental foundation in shaping high-quality human resources who are capable of adapting to the dynamic changes of the times. In this era of digital transformation and globalization, education functions not only as a means of knowledge transfer but also plays a critical role in fostering critical thinking skills, problem-solving abilities, and creativity in facing the complexities of real-life situations. One of the essential aspects of education is mathematics learning, which aims not only to develop cognitive abilities but also to cultivate the mathematical understanding necessary for solving problems in everyday life. According to the standards set by the National Council of Teachers of Mathematics (NCTM), the competencies that must be developed in mathematics learning include understanding, communication, representation, problem-solving, and mathematical connections (Tama et al., 2020).

Mathematics, as an integral part of primary and secondary education, plays a strategic role in shaping logical, critical, and systematic thinking patterns. The ability to understand mathematical concepts serves as a fundamental basis for mastering other subjects as well as for applying mathematics in various real-life contexts (Hermawan et al., 2021; Yani et al., 2019). Mathematical understanding not only requires students to master procedures but also to comprehend the underlying meanings of concepts and functionally connect them in problem-solving processes. This is essential to ensure that students do not merely memorize formulas, but genuinely understand how and when to appropriately apply mathematical concepts.

Nevertheless, the results of the 2022 Programme for International Student Assessment (PISA) indicate that Indonesian students' mathematical literacy remains relatively low. Indonesia ranked 69th out of 81 participating countries, with an average score of 366 falling 106 points below the global average (OECD, 2023). This condition reflects students' limited ability to understand and apply mathematical concepts to real-life situations. These data reinforce concerns that many Indonesian students have yet to develop the capacity to connect mathematical concepts with contextual problems in their surroundings. One contributing factor is the continued use of conventional, teacher-centered instructional approaches that emphasize rote memorization of formulas (Yufentya et al., 2019). Within such approaches, students tend to play a passive role and are rarely given opportunities to explore ideas or engage in meaningful peer discussions.

Various studies have shown that active and participatory learning can enhance students' mathematical understanding (Hikmah, 2017; Rahmat, 2017). Cooperative learning models, grounded in constructivist theory, serve as a relevant alternative as they emphasize collaboration among students in small groups while providing opportunities for discussion and information exchange (Andayani & Jazim, 2016; Silalahi et al., 2024). Group collaboration encourages students to express ideas, question opinions, and construct shared understanding. One cooperative learning model that is particularly effective is Two Stay Two Stray (TS-TS). In this model, two students remain in their group to explain the results of the discussion, while the other two visit different groups to exchange information. This interaction fosters idea sharing and broadens students' perspectives on the material. The TS-TS model not only enhances conceptual understanding but also develops students' communication skills and social responsibility.

The implementation of the TS-TS model is effective in enhancing students' mathematical connections, self-efficacy, and problem-solving abilities (Pulungan, 2018). However, challenges in its implementation remain, such as inefficient time management during group discussions, imbalanced participation among group members, and students' limited collaborative skills (Handayani, 2020; Melikhatun; Aman, 2017). Therefore, a complementary approach is needed to reinforce the effectiveness of the TS-TS model, ensuring that learning objectives are achieved optimally.

Realistic Mathematics Education (RME) is an instructional approach that emphasizes meaningful learning through real-life contexts relevant to students. This approach, developed based on the principle that mathematics should be closely related to reality and actively constructed by students through concrete experiences, is designed to make mathematical concepts more accessible and relevant to students' real-life experiences (Anwar et al., 2024; Ediyanto et al., 2020). The core principles of RME include the use of contextual problems as a starting point for learning, the development of mathematical models, the progression from informal to formal thinking, interactivity, and the interconnectedness of mathematical concepts (Sari & Yuniati, 2018). In practice, RME provides students with opportunities to gradually construct mathematical knowledge, beginning with everyday experiences and advancing toward more formal and abstract conceptual understanding.

Research has shown that the RME approach can enhance students' learning motivation, conceptual understanding, and critical thinking skills (Astuti, 2018; Mendrofa, 2021; Sari & Yuniati, 2018). By integrating the TS-TS cooperative learning model with the RME approach, mathematics instruction becomes more contextual, active, and collaborative. This combination enables students to construct knowledge independently through discussion, exploration, and real-world problem-solving, while also fostering mathematical communication and representation skills (Muchtar et al., 2020; Sari & Azmi, 2018; Yusuf et al., 2020). In addition, such an approach has the potential to create an inclusive learning environment by accommodating diverse student learning styles.

Similarly, Indonesia's national education policy has moved toward student-centered learning. The Regulation of the Minister of Education, Culture, Research, and Technology No. 21 of 2022 on Standards for Primary and Secondary Education states that learning should be interactive, inspiring, fun, and challenging. It should also encourage students to take an active role and give them space to be creative and independent (Kemendikbudristek, 2022).

In the context of mathematics instruction at the junior high school level, particularly in the topic of three-dimensional geometric shapes (solid figures with flat surfaces), a contextual approach is essential to help students tangibly visualize geometric objects. This topic is often perceived as difficult by students due to the complexity of spatial reasoning it requires. Preliminary observations at SMPN 1 Sindangagung indicated that many students struggle to understand the concepts of volume and surface area of solid figures. These difficulties are primarily attributed to the lack of exploratory activities and visual representations during the learning process. Teachers tend to deliver content theoretically, without incorporating manipulatives or concrete contexts that would support students in visualizing three-dimensional shapes.

Based on these considerations, this study aims to investigate the difference in students' mathematical understanding between those taught using the TS-TS model based on the RME approach and those taught using conventional methods. The findings of this study are expected to contribute to the development of mathematics instructional strategies that are more contextual, cooperative, and concept-oriented. Furthermore, the results may serve as a valuable reference for educators in selecting and designing learning approaches that align with students' characteristics and the demands of 21st-century curricula.

METHODS

This study employed a quantitative approach with a quasi-experimental design, specifically a non-equivalent pretest-posttest control group design (Sugiyono, 2018). This design involved two non-randomly selected groups: an experimental group and a control group. The experimental group received instruction using the TS-TS model based on the RME approach, while the control group received conventional instruction without any specific treatment.

The population of this study consisted of all eighth-grade students at SMPN 1 Sindangagung in the 2023/2024 academic year. The sampling technique used was purposive sampling, with class VIII C assigned as the experimental group and class VIII D as the control group. The selection of classes was based on practical considerations and the similarity of class characteristics, by the principles of the non-equivalent control group design, which does not require randomization (Abraham & Superiyati, 2022; Sugiyono, 2018).

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Source : Lestari & Yudhanegara (2017)

Information:

O_1 dan O_3 : Pretest value (before treatment)
X : Treatment in the form of a TS-TS learning model with an RME approach
O_2 dan O_4 : Posttest value (after treatment)

The research instrument consisted of open-ended questions designed to assess students' mathematical understanding based on several indicators: restating concepts, providing examples and non-examples, representing concepts, developing necessary and sufficient conditions, and applying concepts in problem-solving. Before implementation, the instrument was tested to ensure its validity and reliability by quantitative research standards.

The research procedure began with a pretest administered to both groups, followed by the treatment given to the experimental group, and concluded with a posttest for both groups. The pretest and posttest data were analyzed using Microsoft Excel.

Data analysis included calculating the improvement in students' understanding using the N-Gain formula, with the following criteria:

Table 2. N-Gain Criteria

N-Gain Score	Interpretation
$0{,}70 \le g \le 100$	High
$0{,}30 \le g < 0{,}70$	Moderate
$0{,}00 < g < 0{,}30$	Low

The normality of the data was tested using the Chi-Square test, with data considered normally distributed if the significance value was greater than 0,05. Homogeneity was tested using an F-test, with data deemed homogeneous if the significance value was greater than 0,05. If the data were not normally distributed, the non-parametric Mann–Whitney U test was employed to determine differences between the experimental and control groups, with results considered significant at a p-value of less than 0,05. The quasi-experimental design was chosen due to limitations in randomizing research subjects. This design allows for the examination of treatment effectiveness while controlling for external variables that may influence the results.

RESULTS AND DISCUSSION

This study aims to examine the improvement of students' conceptual understanding of mathematics at SMPN 1 Sindangagung through the implementation of the TS-TS cooperative learning model integrated with the RME approach. Realistic Mathematics Education is an instructional approach that utilizes real-life problems relevant to students' daily experiences, enabling them to construct mathematical concepts in a meaningful and contextually relevant manner by drawing upon their unique abilities during learning activities grounded in real-world contexts and surroundings (Hairun et al., 2024; Ma'arif & Sutarni, 2023).

Before the treatment, a test instrument trial was conducted with Grade IX students who had previously studied the topic of three-dimensional geometric shapes. The instrument was analyzed for validity, reliability, discriminating power, and difficulty level to ensure the quality of the assessment used to measure students' conceptual understanding. Based on the analysis results, five valid items were selected and used as the pretest and posttest instruments for both the experimental and control groups.

The pretest data were analyzed using the Chi-Square normality test, which revealed that the data in both groups were not normally distributed, as the calculated χ^2 value exceeded the critical χ^2 value. Consequently, a non-parametric test was employed for further analysis. This condition indicates that students' initial abilities varied and did not follow a normal distribution pattern; therefore, the Mann-Whitney U test was used to compare the initial abilities between the two groups (Farokhah et al., 2019; Hidayat et al., 2020; Sari & Yuniati, 2018).

Table 3. Pretest Normally Test Results

Group	Chi-Square	
	χ^2_{hitung}	χ^2_{tabel}
Experiment	115,4	11,07
Control	99,12	

The pretest data from both classes indicated a not normally distributed. This condition was attributed to students' low initial ability to understand mathematical concepts, as reflected by the wide dispersion and inconsistency in their initial scores. Based on interviews with the mathematics teacher at SMP Negeri 1 Sindangagung, students were still struggling to solve varied types of problems, were not yet accustomed to restating previously learned material, and were generally hesitant to ask questions when encountering difficulties. These findings illustrate the lack of student engagement in the learning process. To address these issues, instruction should adopt an approach that actively involves students, such as the RME approach, which connects mathematical content to concrete experiences (Hidayat et al., 2020). In addition, RME links mathematical concepts to students' real-life experiences, thereby facilitating understanding and enhancing active participation in the learning process (Fahrudin et al., 2018).

Table 4. Pretest Homogeneity Test Results

Group	F-Test		
	Variance	F_{hitung}	F_{tabel}
Experiment	130,76	4,32	1,98
Control	564,44		

The data indicate that the variance between classes was not homogeneous, reflecting significant disparities in score distribution among students, particularly in the control group. This variation can be attributed to the absence of an instructional approach that accommodates diverse learning styles and student abilities equitably. Such a condition reinforces the need for collaborative and participatory learning models, such as the TS-TS model, which facilitates peer interaction and knowledge transfer within groups. This model has been shown to effectively enhance mathematics learning outcomes through active group work and information exchange during the learning process (Akhmad & Wijayanti, 2016; Rachmawati et al., 2020).

Table 5. Pretest Similarity Test Results

Z_{hitung}	Z_{tabel}
0,56	1,645

There was a significant difference in the initial mathematical ability between the experimental and control classes, indicating that both groups were not at an equivalent starting point before the intervention. In educational research, this condition is important to consider to avoid bias when assessing the effectiveness of an instructional treatment. Focusing solely on post-test scores can lead to misleading conclusions, as it disregards students' prior knowledge. Students with higher initial ability tend to achieve high post-test scores even without meaningful instructional intervention, whereas those with lower prior ability may demonstrate substantial improvement, even if their final scores remain comparatively lower (Suwaji et al., 2019; Une et al., 2023). Therefore, a more equitable and proportional measure is to examine learning progress through normalized gain (N-Gain) scores. This study compares the mean N-Gain scores between the two groups to more accurately evaluate the effectiveness of the instructional model.

Table 6. N-Gain Test Results

Group	Average N-Gain
Experiment	0,59
Control	0,52

In the experimental class, the average N-Gain score was 0,59 (moderate category), while the control class obtained an average of 0,52 (also in the moderate category). Although both scores fall within the same category, the higher N-Gain in the experimental class indicates that the TS-TS model combined with the RME approach is more effective in enhancing students' conceptual understanding of mathematics compared to conventional instruction.

The use of N-Gain scores in this study aims to assess students' learning improvement proportionally from the initial condition (pretest) to the final condition (posttest). The slightly higher score observed in the experimental class suggests a positive influence from the implementation of the TS-TS model combined with the RME approach, although the difference is not statistically significant. Activities such as group discussions and inter-group visits in the TS-TS model encouraged students to actively think, exchange ideas, and construct understanding through concrete learning experiences. These findings are consistent with previous studies indicating that the RME approach is effective in enhancing students' conceptual understanding of mathematics and that the TS-TS model yields better outcomes compared to conventional instruction (Rahayu & Muhtadi, 2022; Rahmat, 2017).

Table 7. N-Gain Normality Test Results

Group	Chi-Square	
	χ^2_{hitung}	χ^2_{tabel}
Experiment	100,6	11,07
Control	109,07	

The N-Gain data in both classes were also found to be not normally distributed based on the results of the normality test. Therefore, non-parametric tests were employed for further analysis.

Table 8. N-Gain Homogeneity Test Results

Group	F-Test		
	Variance	F_{hitung}	F_{tabel}
Experiment	1037,92	1,06	1,98
Control	931,586		

The homogeneity of variance test was conducted to ensure that both groups exhibited uniform variance, thereby fulfilling the assumptions required for between-group comparative analysis. Homogeneous data allow for the valid application of the Mann-Whitney U test to examine differences in learning gains. Meeting this assumption is crucial to maintain the accuracy of research result interpretation, particularly in educational studies where student ability levels may vary significantly. With the homogeneity assumption met, the comparison between the experimental and control classes can be carried out more precisely, and the results can be scientifically justified.

Table 9. N-Gain Comparison Test Results

Mann Whitney U	
Z_{hitung}	Z_{tabel}
1,004	1,645

The results of the study indicate that learning using the TS-TS model combined with the RME approach is more effective in improving students' conceptual understanding of mathematics. Active student engagement throughout the learning process, from problem exploration, and group discussions, to information exchange through intergroup visits, encourages understanding that is not only procedural but also conceptual. These findings are consistent with previous studies which state that the combination of the RME approach and the TS-TS model can significantly enhance students' mathematics learning outcomes (Febriana, 2023; Khairunnisa & Masrukan, 2020; Sari & Yuniati, 2018). However, the effectiveness of this learning approach may be influenced by several factors, such as students' readiness to actively participate, time constraints, and the lack of teachers' experience in optimally implementing the TS-TS model based on RME. The limited improvement in conceptual understanding may also be attributed to the insufficient training and guidance provided to teachers in managing collaborative and contextual learning comprehensively.

These findings align with previous research, which asserts that the effectiveness of cooperative learning models is strongly influenced by the preparedness of teachers and students to engage in an active and collaborative learning process. Furthermore, the importance of providing training and ongoing support to teachers in implementing RME-based instructional models is emphasized to enhance the quality of interaction and student engagement significantly (Febriana, 2023; Putri Nurwijayanti et al., 2023).

Overall, the results of this study reinforce previous findings that cooperative learning models integrated with real-life contextual approaches have a positive impact on students' mathematical conceptual understanding. The TS-TS model offers opportunities for students to actively engage in discussion, exchange ideas, and reinforce concepts collaboratively, while the RME approach supports students in relating mathematical material to real-life situations, enabling them to construct knowledge independently and meaningfully. Although the statistical difference in learning gains was not significant, this instructional model is practically viable as an effective and contextual learning strategy for mathematics at the junior high school level. In addition, RME-based instruction has been proven to enhance student activity, learning outcomes, and mathematical connection abilities by providing contextual learning experiences and linking concepts to students' real-world experiences (Khotimah et al., 2024; Sinaga et al., 2022; Siskawati et al., 2022; Utarni & Mulyatna, 2020).

CONCLUSION

This study demonstrates that the implementation of the Two Stay Two Stray cooperative learning model based on the Realistic Mathematics Education approach has a significant impact on enhancing the mathematical conceptual understanding of eighth-grade students at SMPN 1 Sindangagung in the topic of three-dimensional geometric shapes with flat surfaces. The combination of the TS-TS cooperative model and the contextual RME approach has proven effective in supporting students to develop a deeper understanding of mathematical concepts while simultaneously improving their communication and collaboration skills. Therefore, the application of this instructional model can serve as a suitable alternative in designing mathematics learning processes that are more active, collaborative, and aligned with current educational needs.

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