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STAD COOPERATIVE LEARNING WITH WORKSHEETS FOR MATHEMATICAL PROBLEM SOLVING IN A NUMERACY CONTEXT

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Abstract
This study examined the effect of Student Teams Achievement Divisions (STAD) cooperative learning supported by student worksheets on seventh-grade students' mathematical problem-solving ability (MPSA) in a numeracy context. A quasi-experimental non-equivalent control group pretest–posttest design was used, with one class assigned as the experimental group and another as the control group. Data were collected using essay-type pretest and posttest instruments scored using four indicators derived from Pólya's problem-solving framework: understanding the problem, devising a plan, carrying out the plan, and looking back. Data were analysed using descriptive statistics and analysis of covariance (ANCOVA), with pretest scores treated as a covariate. ANCOVA results showed a significant effect of instructional group on posttest MPSA after controlling for initial ability, and the pretest covariate significantly predicted posttest performance. Indicator-level ANCOVA indicated that the strongest group differences occurred in understanding the problem and devising a plan, while no significant difference was found for carrying out and checking the solution. These findings suggest that STAD supported by worksheets contributes particularly to students' early-stage problem-solving processes in numeracy-oriented mathematics learning. Results should be interpreted cautiously due to the non-randomized design and limited number of test items.

Keywords: cooperative learning, numeracy, problem-solving, student teams achievement divisions, worksheet.

Abstrak
Penelitian ini mengkaji pengaruh pembelajaran kooperatif tipe Student Teams Achievement Divisions (STAD) yang didukung lembar kerja siswa terhadap kemampuan pemecahan masalah matematis (KPMM) siswa kelas VII dalam konteks numerasi. Penelitian menggunakan desain kuasi-eksperimen non-equivalent control group pretest–posttest, dengan satu kelas sebagai kelompok eksperimen dan satu kelas sebagai kelompok kontrol. Data dikumpulkan melalui tes uraian pretest dan posttest yang dinilai menggunakan empat indikator yang diturunkan dari kerangka pemecahan masalah Pólya, yaitu memahami masalah, menyusun rencana penyelesaian, melaksanakan rencana, dan memeriksa kembali penyelesaian. Analisis data dilakukan dengan statistik deskriptif dan analisis kovarians (ANCOVA) dengan skor pretest sebagai kovariat. Hasil ANCOVA menunjukkan adanya pengaruh signifikan kelompok pembelajaran terhadap skor postest KPMM setelah mengontrol kemampuan awal, dan skor pretest berkontribusi signifikan dalam memprediksi skor postest. Analisis ANCOVA per indikator menunjukkan perbedaan paling kuat pada indikator memahami masalah dan merencanakan penyelesaian, sedangkan pada indikator melaksanakan dan memeriksa kembali penyelesaian tidak ditemukan perbedaan signifikan. Temuan ini mengindikasikan STAD berbantuan lembar kerja terutama mendukung tahapan awal proses pemecahan masalah dalam pembelajaran matematika berbasis numerasi. Hasil perlu ditafsirkan hati-hati karena desain non-random dan jumlah butir soal terbatas.

Kata kunci: *kemampuan pemecahan masalah, lembar kerja siswa, numerasi, pembelajaran kooperatif, student teams achievement divisions.*

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INTRODUCTION

International frameworks and contemporary curriculum discussions emphasize that mathematics learning should develop key competencies such as problem solving, reasoning, communication, and representation (OECD, 2023; Foster, 2023; Schoenfeld, 2022). From the perspective of modern mathematics education, mathematical problems are not viewed merely as routine practice exercises. Instead, they are situations that require students to formulate, interpret, and solve problems when solution procedures are not immediately available. Schoenfeld (2022) points out that the main difficulty in mathematics learning lies in students' thinking processes when they must understand a context, select appropriate strategies, and monitor and evaluate the solutions they produce. Therefore, mathematics instruction should ideally present problems that require reasoning and decision making, rather than simply the application of algorithms. In line with this perspective, international curricula and assessments position numeracy as an essential competence for the 21st century. The OECD (2019, 2023) defines numeracy as an individual's ability to formulate, use, and interpret mathematics in a variety of real-world contexts. Numeracy requires students to understand contextual situations, model them mathematically, apply relevant concepts and procedures, and interpret solutions critically (Askew, 2015; Geiger et al., 2015). Thus, numeracy is more appropriately understood as a learning context rather than merely a collection of computational skills.

In this study, numeracy is positioned as the learning context, while the main ability being measured is students' mathematical problem-solving ability (MPSA). MPSA in a numeracy context refers to students' capacity to understand contextual problems, plan solution strategies, carry out those strategies, and review the correctness of the results obtained. This framework aligns with the problem-solving stages proposed by Pólya (1973), which are still considered a foundational framework in mathematics education research because they systematically describe students' thinking processes. Although mathematical problem solving in a numeracy context is a highly important competence, many international studies indicate that this ability remains a challenge for many students, including those in Indonesia. Results from the Programme for International Student Assessment (PISA) show that a large proportion of Indonesian students experience difficulties in solving contextual mathematics problems that require reasoning, modeling, and interpretation of results (OECD, 2019; OECD, 2023). These findings suggest that students are not yet accustomed to applying systematic problem-solving steps when dealing with numeracy problems, even when they have learned the relevant mathematical concepts.

To address this issue, instructional strategies are needed that do not focus solely on content delivery but also encourage active student engagement in thinking and problem solving. One approach that is widely recommended in the mathematics education literature is cooperative learning. Slavin (2015) explains that cooperative learning, particularly the Student Teams Achievement Divisions (STAD) model, emphasizes collaboration in heterogeneous groups, individual accountability, and structured social interaction to build shared conceptual understanding. Through group discussions and peer tutoring, students have opportunities to articulate ideas, test strategies, and reflect on their problem-solving processes. In addition to instructional models, the quality of tasks and learning materials is crucial. Worksheets and well-designed 'rich tasks' can prompt students to interpret contexts, represent information, choose and justify strategies, and reflect on solutions—key processes in mathematical problem solving in a numeracy context (Russo, 2020; Papadopoulos, 2020; Ng, 2023; Canogullari & Radmehr, 2025).

Although cooperative learning and the use of student worksheets (SWs) have been widely studied, research that specifically integrates STAD cooperative learning with SWs in a numeracy learning context for seventh-grade junior high school students remains limited. Furthermore, there is still a need for studies that explicitly position numeracy as a learning context and use Pólya's problem-solving indicators as the basis for measuring students' thinking processes (Luthfi & Murtiyasa, 2024; Pradana, 2024; Wen Chun & Su Wei, 2015; Yee & Bostic, 2014). Therefore, this study aims to analyze the effect of STAD supported by SWs, hereafter referred to as STAD–SWs, on students' MPSA in a numeracy context. Operationally, this study seeks to answer the following research question: Is there a difference in MPSA between students who participate in STAD–SWs and those who receive CI (conventional instruction) in a numeracy context?

METHODS

This study employed a quantitative approach using a quasi-experimental method. The use of a quasi-experimental design was based on the fact that the classes had already been naturally formed, making it impossible to randomly assign students to groups (Ary et al., 2019). The research design was a nonrandomized control group pretest–posttest design involving two groups: an experimental group and a control group. Both groups were given a pretest and a posttest to measure students' MPSA in a numeracy context. The experimental group received instruction through STAD–SWs containing contextual numeracy tasks, while the control group received CI. The research design is presented in Table 1.

Table 1
Research Design

Group	Pretest	Treatment	Posttest
Experimental	O_1	STAD − SWs	O_2
Control	O_3	-	O_4

Notes:
O_1 = Pretest score of the experimental group
O_2 = Posttest score of the experimental group
O_3 = Pretest score of the control group
O_4 = Posttest score of the control group
STAD − SWs = student teams achievement divisions cooperative learning supported by student worksheets

Population and Sample

The population of this study consisted of all seventh-grade students at SMP Negeri 14 Tarakan, comprising four classes (VII-1, VII-2, VII-3, and VII-4) with a total of 128 students. The research sample consisted of two classes selected as the experimental and control groups. Cluster sampling was used, in which intact classes were selected as research samples (Ary et al., 2019). Based on a random draw, class VII-2 was assigned as the experimental group and class VII-1 as the control group, with an initial total of 32 students in each class. During the implementation of the study, some students did not participate in all learning sessions and tests. As a result, the final sample analyzed consisted of 57 students: 29 students in the experimental group and 28 students in the control group. Data analysis was conducted only on students who completed both the pretest and the posttest.

Learning Materials, Test Instruments, and Lesson Implementation Observation

Learning Materials

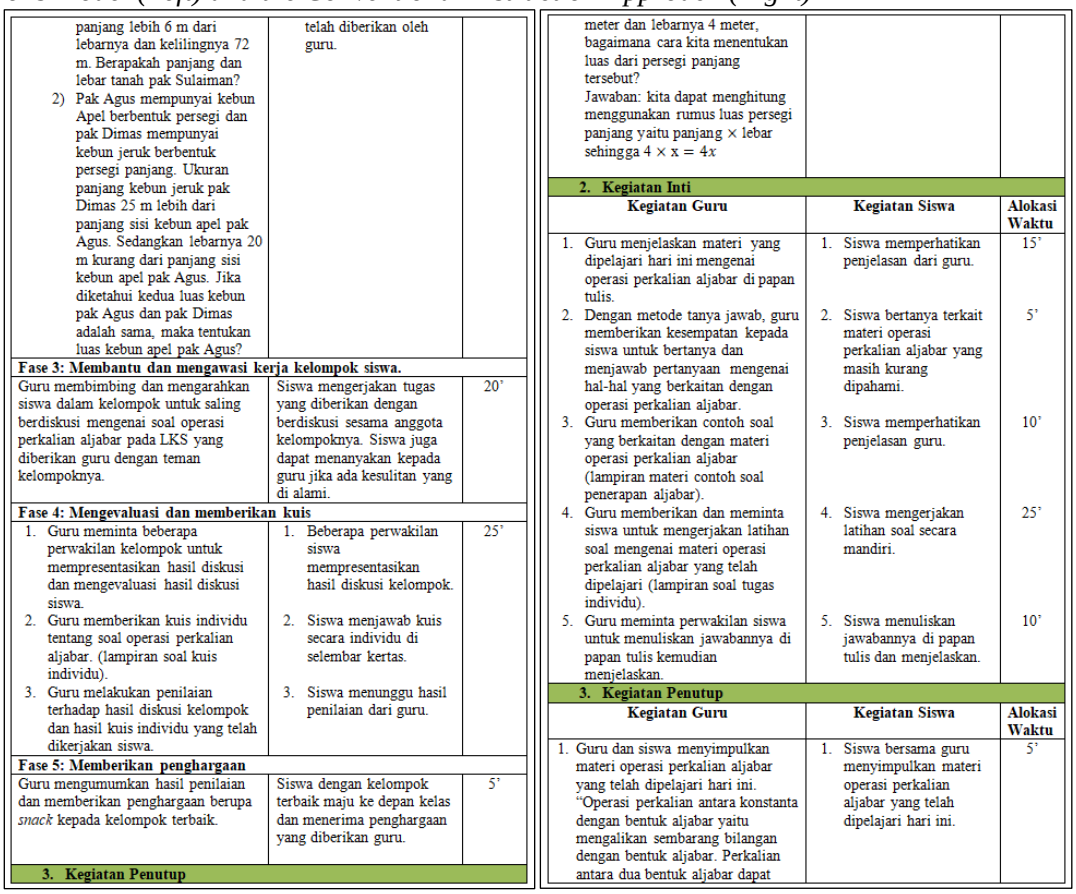
In this study, numeracy was positioned as a learning context rather than as a separately measured variable. Numeracy-based learning was implemented through contextual problems that represent real-life situations and require students to formulate mathematical models, apply relevant mathematical concepts and procedures, and interpret and evaluate the solutions obtained. This approach is consistent with the numeracy framework proposed by the OECD (2019, 2023).

Teaching Modules

Two types of teaching modules (TMs) were used in this study: STAD modules for the experimental group and CI modules for the control group (see Figure 1). Both modules were designed for three instructional sessions on algebra topics, specifically the multiplication of algebraic expressions, and followed a systematic and consistent structure. In general, each module included: (1) subject identity and learning objectives, (2) an explanation of core algebra content, (3) step-by-step learning activities, and (4) evaluation activities.

Figure 1

Appearance of the Teaching Module for Cooperative Learning Using the Student Teams Achievement Divisions Model (Left) and the Conventional Instruction Approach (Right)



panjang lebih 6 m dari lebarnya dan kelilingnya 72 m. Berapakah panjang dan lebar tanah pak Sulaiman? 2) Pak Agus mempunyai kebun Apel berbentuk persegi dan pak Dimas mempunyai kebun jeruk berbentuk persegi panjang. Ukuran panjang kebun jeruk pak Dimas 25 m lebih dari panjang sisi kebun apel pak Agus. Sedangkan lebarnya 20 m kurang dari panjang sisi kebun apel pak Agus. Jika diketahui kedua luas kebun pak Agus dan pak Dimas adalah sama, maka tentukan luas kebun apel pak Agus?	telah diberikan oleh guru.	
Fase 3: Membantu dan mengawasi kerja kelompok siswa.		
Guru membimbing dan mengarahkan siswa dalam kelompok untuk saling berdiskusi mengenai soal operasi perkalian aljabar pada LKS yang diberikan guru dengan teman kelompoknya.	Siswa mengerjakan tugas yang diberikan dengan berdiskusi sesama anggota kelompoknya. Siswa juga dapat menanyakan kepada guru jika ada kesulitan yang di alami.	20'
Fase 4: Mengevaluasi dan memberikan kuis		
1. Guru meminta beberapa perwakilan kelompok untuk mempresentasikan hasil diskusi dan mengevaluasi hasil diskusi siswa. 2. Guru memberikan kuis individu tentang soal operasi perkalian aljabar. (lampiran soal kuis individu). 3. Guru melakukan penilaian terhadap hasil diskusi kelompok dan hasil kuis individu yang telah dikerjakan siswa.	1. Beberapa perwakilan siswa mempresentasikan hasil diskusi kelompok. 2. Siswa menjawab kuis secara individu di selembar kertas. 3. Siswa menunggu hasil penilaian dari guru.	25'
Fase 5: Memberikan penghargaan		
Guru mengumumkan hasil penilaian dan memberikan penghargaan berupa *snack* kepada kelompok terbaik.	Siswa dengan kelompok terbaik maju ke depan kelas dan menerima penghargaan yang diberikan guru.	5'
3. Kegiatan Penutup		

meter dan lebarnya 4 meter, bagaimana cara kita menentukan luas dari persegi panjang tersebut? Jawaban: kita dapat menghitung menggunakan rumus luas persegi panjang yaitu panjang × lebar sehingga $4 \times x = 4x$		
2. Kegiatan Inti		
Kegiatan Guru	**Kegiatan Siswa**	**Alokasi Waktu**
1. Guru menjelaskan materi yang dipelajari hari ini mengenai operasi perkalian aljabar di papan tulis.	1. Siswa memperhatikan penjelasan dari guru.	15'
2. Dengan metode tanya jawab, guru memberikan kesempatan kepada siswa untuk bertanya dan menjawab pertanyaan mengenai hal-hal yang berkaitan dengan operasi perkalian aljabar.	2. Siswa bertanya terkait materi operasi perkalian aljabar yang masih kurang dipahami.	5'
3. Guru memberikan contoh soal yang berkaitan dengan materi operasi perkalian aljabar (lampiran materi contoh soal penerapan aljabar).	3. Siswa memperhatikan penjelasan guru.	10'
4. Guru memberikan dan meminta siswa untuk mengerjakan latihan soal mengenai materi operasi perkalian aljabar yang telah dipelajari (lampiran soal tugas individu).	4. Siswa mengerjakan latihan soal secara mandiri.	25'
5. Guru meminta perwakilan siswa untuk menuliskan jawabannya di papan tulis kemudian menjelaskan.	5. Siswa menuliskan jawabannya di papan tulis dan menjelaskan.	10'
3. Kegiatan Penutup		
Kegiatan Guru	**Kegiatan Siswa**	**Alokasi Waktu**
1. Guru dan siswa menyimpulkan materi operasi perkalian aljabar yang telah dipelajari hari ini. "Operasi perkalian antara konstanta dengan bentuk aljabar yaitu mengalikan sembarang bilangan dengan bentuk aljabar. Perkalian antara dua bentuk aljabar dapat	1. Siswa bersama guru menyimpulkan materi operasi perkalian aljabar yang telah dipelajari hari ini.	5'

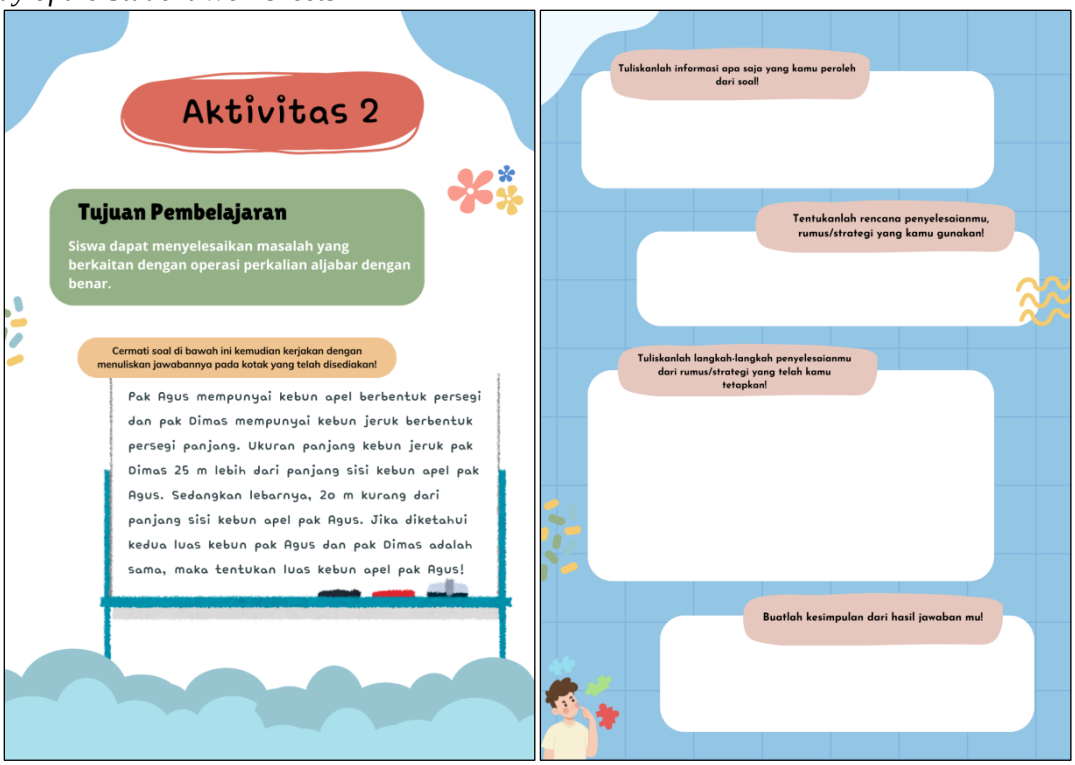
In the STAD module, learning activities were designed according to the STAD instructional sequence, which includes presenting information, organizing students into heterogeneous groups, guiding and monitoring group discussions, evaluating learning through individual quizzes, and providing group rewards. The module explicitly directs teachers to facilitate group discussions using numeracy-based student worksheets and to encourage interaction among students while solving contextual algebra problems. In contrast, the CI module was designed using a teacher-centered approach, which reflects the instructional practices commonly applied by mathematics teachers at the research site. In this module, the teacher explains algebraic concepts, principles, and properties through direct instruction, followed by worked examples, step-by-step solution explanations, and individual practice exercises. Student interaction in the CI module is more limited than in the STAD module, and group discussion is not a central component of instruction. The teaching modules were validated by three validators—two mathematics education lecturers and one mathematics teacher. The validation results showed an average score of 3.51 on a 4.00 scale, which falls into the very relevant category, indicating that the modules were appropriate for use in this study.

Student Worksheets

The student worksheets (SWs) in this study were specifically designed to support learning in a numeracy context and to develop students' MPSA. The worksheets were used as the main learning tool in the experimental class and were directly integrated into STAD group discussion activities. As shown in the worksheet display (Figure 2), each activity begins with clearly stated learning objectives that emphasize the competencies students are expected to achieve. Next, the worksheets present contextual problems that are closely related to students' everyday lives, such as problems involving the area of square and rectangular gardens that require algebraic operations. These problems are

designed to represent numeracy contexts, requiring students to understand real-life situations, translate them into mathematical models, and interpret the resulting solutions.

Figure 2
Display of the Student Worksheets



The structure of the worksheets is systematically organized according to Pólya's problem-solving stages: (1) writing down the information given in the problem (understanding the problem); (2) determining a plan or strategy for solving the problem; (3) writing the mathematical steps used to carry out the solution; and (4) drawing conclusions or reflecting on the obtained answers. Blank spaces are provided at each stage so that students focus not only on the final answer but also on the thinking process and problem-solving strategies they use. In this way, the worksheets function as scaffolding that guides students through a structured and reflective problem-solving process. The developed worksheets were validated by the same three validators who reviewed the teaching modules. The validation results showed that the worksheets obtained an average score of 3.26 on a 4.00 scale, which falls into the very relevant category. Therefore, the worksheets are considered appropriate for developing students' MPSA in a numeracy context.

Test Instruments

The test items and scoring rubric were developed based on Pólya's (1973) four stages of mathematical problem solving: understanding the problem, devising a plan, carrying out the plan, and looking back. Students' responses were evaluated using an analytic scoring rubric aligned with these stages. Scores were assigned according to the completeness and correctness of the responses, ranging from 0 to 3 for the first three stages and from 0 to 2 for the looking-back stage.

Lesson Implementation Sheets

Observation sheets were used to monitor the implementation of learning activities in both the experimental and control groups. The lesson implementation sheet (LIS) for the experimental group was developed based on the syntax of the STAD cooperative learning model, whereas the sheet for the control group was based on the procedures of conventional instruction (CI). The LIS was validated by three experts and received average scores of 3.29 for the experimental class and 3.33 for the control class on a 4.00 scale, both categorized as very relevant. The observation results were used

to ensure that the instructional treatments were implemented in accordance with the planned procedures.

Research Procedure

This study was conducted in three main stages: preparation, implementation, and evaluation. The preparation stage included the development and validation of TMs, SWs, MPSA test instruments, and LISs. The implementation stage was the core phase of the study, involving the application of STAD learning in the experimental class and CI in the control class. The evaluation stage involved administering the posttest and conducting data analysis.

Implementation of Learning in the Experimental Class

Learning in the experimental class was conducted using the STAD model. STAD was applied consistently over three class meetings on algebra topics. The implementation of STAD followed the syntax proposed by Slavin (2015), which emphasizes group cooperation, individual accountability, and evaluation based on improvement in learning outcomes. Operationally, the STAD cooperative learning syntax used in this study is presented in Table 2.

Table 2

Syntax of the Student Teams Achievement Divisions Cooperative Learning Model

Phase	Teacher Activities	Student Activities
Presenting information	The teacher explains algebra-related concepts, principles, and properties to the whole class.	Students pay attention to the teacher's explanation and take notes on important information.
Organizing students into learning groups	The teacher divides students into heterogeneous groups of 4–5 students based on academic ability.	Students form groups according to the teacher's instructions.
Assisting and monitoring group work	The teacher guides, monitors, and assists groups that experience difficulties during discussion.	Students discuss tasks and solve worksheet problems together with their group members.
Evaluating group discussion results	The teacher evaluates group discussion results and facilitates group presentations.	Students present their group work and respond to presentations from other groups.
Administering individual quizzes	The teacher gives individual quizzes to be completed without assistance from peers.	Students complete the quizzes independently.
Giving rewards	The teacher provides rewards to the best groups based on individual and group score improvements.	Students in the best-performing groups receive rewards.

Through these stages, students not only gained individual conceptual understanding but also had opportunities to develop MPSA through discussion, peer tutoring, and reflection on the solutions produced. Numeracy-based worksheets (SWs) were used as the main tool to guide students through Pólya's problem-solving stages, from understanding the problem to looking back at the final solution.

Implementation of Learning in the Control Class

Learning in the control class was carried out using teacher-centered. In this approach, the teacher directly explained algebra-related concepts, principles, and properties at the front of the classroom. The teacher then provided example problems and explained the steps for solving them. After that, students were asked to work on practice problems individually based on the given examples. In CI, student interaction was relatively limited, and group discussion was not a major component of instruction. The practice problems were mostly procedural in nature, which limited students' opportunities to explore problem-solving strategies and connect mathematics to real-life contexts compared to STAD-based learning.

Evaluation Stage

The evaluation stage was conducted by administering a posttest to both groups after all learning activities were completed. The posttest was used to measure students' MPSA in a numeracy context based on Pólya's problem-solving indicators. The posttest data were then analyzed to determine differences in MPSA between students who participated in STAD–SWs and those who participated in CI.

Data Analysis Techniques

Inferential analysis was conducted using analysis of covariance (ANCOVA) to test the research hypothesis. In the ANCOVA model, posttest scores were treated as the dependent variable, instructional group as the fixed factor, and pretest scores as the covariate. Before hypothesis testing, prerequisite tests were conducted, including normality and homogeneity tests, with a significance level of 5% ($\alpha = 0.05$).

$H_0: \mu_1 = \mu_3$

$H_a: \mu_1 \neq \mu_3$

Final condition hypothesis (posttest):

$H_0: \mu_2 \leq \mu_4$

$H_a: \mu_2 > \mu_4$

Where:

μ_1: Mean MPSA score of the experimental group on the pretest

μ_2: Mean MPSA score of the experimental group on the posttest

μ_3: Mean MPSA score of the control group on the pretest

μ_4: Mean MPSA score of the control group on the posttest

RESULTS AND DISCUSSION

Research Results

Descriptive analysis was conducted to describe students' MPSA in a numeracy context for both the experimental group and the control group. A summary of the descriptive analysis results is presented in Table 3. The experimental group consisted of 29 students, while the control group consisted of 28 students. The mean pretest score of the experimental group was 55.86 with a standard deviation of 12.60, whereas the control group had a mean pretest score of 52.87 with a standard deviation of 17.57. These results indicate that the initial abilities of the two groups were relatively comparable before the instructional treatment was applied. After the learning intervention, the mean posttest score of the experimental group increased to 78.49 with a standard deviation of 12.39, while the mean posttest score of the control group increased to 67.82 with a standard deviation of 13.80. The gain score (the difference between pretest and posttest) for the experimental group was 22.63, which is higher than the gain score of the control group, which was 14.95. These findings indicate that the improvement in students' MPSA in the experimental group was greater than that in the control group.

Table 3

Descriptive Analysis of the Mathematical Problem-Solving Ability Test

Class	Test	N	Min	Max	$\bar{X}$	Sd
Experimental	*Pretest*	29	30.00	76.00	55.86	12.60
	Posttest	29	48.00	100.00	78.49	12.39
Control	*Pretest*	28	6.00	79.00	52.87	17.57
	Posttest	28	42.00	100.00	67.82	13.80

Inferential analysis was conducted using ANCOVA to compare posttest MPSA scores between the experimental and control groups while controlling for pretest scores. The results indicated a statistically significant effect of instructional group on posttest scores, $F(1, 54) = 11.621$, $p = 0.001$, with partial $\eta^2 = 0.177$. The covariate (pretest score) was also significant, indicating that students' initial problem-solving ability contributed to posttest performance. To examine which components of

problem solving were most affected, indicator-level ANCOVA was conducted. Significant group effects were found for the indicators of understanding the problem ($F(1, 54) = 12.014$, $p = 0.001$, partial $\eta^2 = 0.182$) and devising a plan ($F(1, 54) = 17.718$, $p < .001$, partial $\eta^2 = 0.247$), while the group effect for carrying out and looking back was not statistically significant ($F(1, 54) = 0.273$, $p = 0.604$).

Figure 3

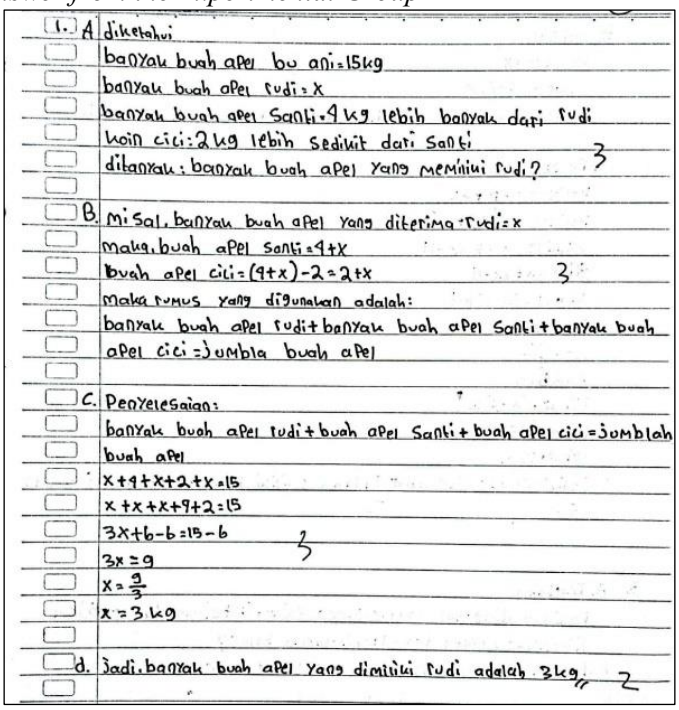
One Example of a Problem from the Mathematical Problem-Solving Ability Posttest

Mrs. Ani has 15 kilograms of apples to be shared among Cici, Santi, and Rudi.
Santi receives 4 kilograms more than Rudi.
Cici receives 2 kilograms less than Santi.
Determine how many kilograms of apples Rudi receives by answering the questions below.
a. Identify the information given in the problem.
b. Make a plan by choosing an appropriate strategy or algebraic expression to solve the problem.
c. Carry out the calculations based on the strategy or formula you chose in part (b).
d. Write a conclusion based on your final answer.

An example of a student's response from the experimental group (Figure 3) shows that the student, coded S.72.28, was able to meet all MPSA indicators. The student demonstrated an understanding of the problem by clearly writing down the given information and what was being asked (understanding the problem), modeled the situation using algebra and planned an appropriate solution strategy (devising a plan), carried out the calculation steps systematically (carrying out the plan), and wrote a conclusion that was consistent with the context of the problem (looking back).

Figure 4

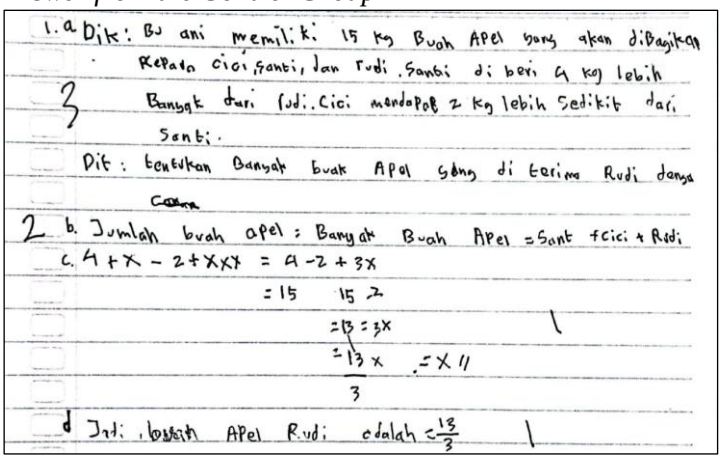
Example of a Student's Answer from the Experimental Group



An example of a student's answer from the control group (Figure 5) shows that the student with the initials S.71.1 had not yet met the problem-solving indicators optimally. The student experienced difficulty in modeling the problem using algebra, which resulted in unsystematic solution steps and a conclusion that was not aligned with the context of the problem. This difference in the quality of

students' responses indicates that STAD learning supported by SWs helps students go through the problem-solving stages in a more structured manner.

Figure 5
Example of a Student's Answer from the Control Group



Discussion

Theoretically, these findings are consistent with the cooperative learning framework developed by Slavin (2015), which emphasizes the importance of positive interdependence, individual accountability, and promotive interaction among students. In STAD, group discussions serve as a vehicle for cognitive elaboration, while individual quizzes ensure that each student is personally responsible for mastering the material. A number of international studies have shown that such cooperative structures are effective in enhancing conceptual understanding and mathematical problem-solving abilities, particularly when students are actively engaged in peer discussion and explanation (Gillies, 2016; Talkhan & Alhubaidah, 2025).

An examination of students' responses further supports the quantitative results. Students in the experimental class showed more systematic fulfillment of all four of Pólya's problem-solving indicators—understanding the problem, planning the solution, carrying out the plan, and looking back—compared to students in the control class. This pattern is consistent with previous research indicating that cooperative learning supports the development of problem-solving strategies through processes of argumentation, clarification, and shared reflection within groups (Gillies, 2016; Talkhan & Alhubaidah, 2025). Beyond the learning model itself, the role of the worksheets as instructional materials was also a key factor in improving students' MPSA. The worksheets used in this study were designed to present contextual numeracy problems along with step-by-step problem-solving guidance that functioned as scaffolding. Recent studies indicate that problem-based and context-rich student worksheets can help learners develop mathematical modeling, reasoning, and reflective thinking skills (Russo, 2020; Wijaya et al., 2015). Such worksheets encourage students not only to solve problems procedurally but also to understand the meaning of mathematics in real-life contexts. Within the numeracy framework, these findings are closely aligned with the perspective developed by the OECD, which emphasizes that numeracy involves the ability to formulate, apply, and interpret mathematics in a variety of real-world situations (OECD, 2019; OECD, 2023). Numeracy-based worksheets help bridge the gap between school mathematics and its application in everyday life by providing meaningful and challenging contexts. This supports the view that numeracy is best positioned as a learning context rather than merely as content or basic computational skill.

The integration of STAD–SWs in this study created a synergy between social interaction and cognitive support. Group discussions in STAD allowed students to elaborate ideas and negotiate meaning, while the worksheets provided structure to guide students' thinking in accordance with Pólya's problem-solving stages. This combination was associated with students' movement from shared understanding toward individual mastery, as reflected in improved individual quiz scores and the shift of students' problem-solving skill categories toward high and very high levels in the

experimental class. This process aligns with contemporary views that emphasize learning activities that promote higher-order thinking and reflective problem solving (Foster, 2023; Schoenfeld, 2022).

Nevertheless, several limitations should be considered. The quasi-experimental design without full randomization limits causal inference, and the test instrument, consisting of only three essay items, restricts the comprehensive measurement of numeracy skills. Therefore, future studies are recommended to employ stronger experimental designs and more diverse, well-validated instruments. In addition, effective implementation of STAD requires teacher readiness in managing group discussions and instructional time so that each stage can be carried out optimally (Slavin, 2015; Gillies, 2016). Overall, the findings of this study indicate that STAD–SWs can be considered an effective approach for developing students' MPSA within the context of this study. These results strengthen the empirical evidence that integrating cooperative learning models with contextual instructional materials can contribute to more meaningful and reflective mathematics learning experiences, particularly in numeracy-oriented contexts.

CONCLUSIONS

Based on the data analysis and discussion, it can be concluded that STAD–SWs in a numeracy context was associated with improved MPSA among Grade VII students at SMP Negeri 14 Tarakan. After controlling for initial ability using ANCOVA, students in the experimental group achieved significantly higher posttest scores than those in the control group, with the strongest differences observed in the indicators related to understanding the problem and devising a plan. Despite these positive outcomes, the findings should be interpreted with caution because the quasi-experimental design without full randomization and the limited number of test items restrict generalizability.

Based on the findings and limitations of this study, several recommendations can be proposed. Mathematics teachers are encouraged to consider STAD–SWs as an alternative instructional strategy, particularly for fostering students' problem-solving abilities in numeracy-based learning. The use of SWs that incorporate contextual problems, structured problem-solving scaffolds, and spaces for reflection may help students approach mathematical problems in a more organized and reflective manner. Teachers should also pay close attention to time management and group dynamics to ensure that each stage of the STAD model is implemented effectively. At the institutional level, schools are encouraged to support the implementation of cooperative learning by providing adequate instructional resources, developing contextual learning materials, and facilitating professional development related to cooperative learning strategies and SW design. For future research, it is recommended to employ more rigorous experimental designs with greater randomization where feasible, as well as assessment instruments with a larger number of test items and stronger reliability evidence. Further studies may also investigate the long-term effects of STAD–SWs on the transfer of students' problem-solving skills across different numeracy contexts or explore its integration with other instructional approaches relevant to mathematics education.

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