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Implementation of the Student Teams Achievement Divisions (STAD) Cooperative Learning Method to Improve Eighth-Grade Students' Mathematics Learning Outcomes

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Abstract

Low mathematics achievement and limited classroom participation indicated the need for a more collaborative instructional approach in Grade 8A at Santo Yusup Pacet Junior High School. This study aimed to improve students' learning outcomes on the Pythagorean Theorem through the Student Teams Achievement Divisions (STAD) cooperative learning model. Classroom Action Research was conducted with 35 eighth-grade students during the first semester of the 2025/2026 academic year through two cycles of planning, action, observation, and reflection. STAD was implemented through class presentation, heterogeneous group work, peer tutoring, individual assessment, and group recognition. Data were collected using achievement tests, classroom observations, and field notes and analyzed descriptively, with 70% classical mastery established as the success criterion. The mean achievement score increased from 69.77 in Cycle I to 81.29 in Cycle II, while classical mastery improved from 37.14% to 74.29%, exceeding the predetermined criterion in Cycle II. Reflection after Cycle I identified students' limited adaptation to cooperative learning, leading to strengthened peer-tutoring roles, clearer group responsibilities, and more explicit group recognition in Cycle II. Following these refinements, students demonstrated improved mathematics achievement and greater participation in collaborative activities. The findings indicate that iterative implementation of STAD can support mathematics learning outcomes and classroom participation in the studied context.

Keywords: *Classroom action research, Cooperative learning, Mathematics achievement, Pythagorean theorem, STAD.*

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I. INTRODUCTION

Mathematics education at the junior high school level plays an important role in developing logical, analytical, critical, and problem-solving skills. Mathematics learning should therefore extend beyond computational procedures by enabling students to understand conceptual relationships, justify their reasoning, select appropriate strategies, and apply mathematical knowledge in different contexts. These competencies require learning environments in which students actively construct understanding through exploration, discussion, argumentation, and problem solving (Ayu et al., 2023; Jannah & Habiby, 2023; Gunawan & Nurtiyasari, 2022; Hamid & Makassar, 2025; Norzilawati et al., 2024). Teacher-centered instruction, in contrast, may restrict academic interaction and limit students' opportunities to participate actively in constructing mathematical knowledge.

This problem was evident in Grade 8A at Santo Yusup Pacet Junior High School. An initial mathematics assessment showed that only 6 of 35 students (17.14%) met the Minimum Mastery Criterion, whereas 29 students (82.86%) had not yet achieved mastery; the class mean was 58.29. This assessment represented students' initial mathematics achievement rather than a pretest identical to the Pythagorean Theorem assessment used during the intervention. Classroom observations further revealed limited peer interaction and discussion, with some students relying heavily on teacher explanations or academically stronger classmates. The instructional problem therefore involved not only low achievement but also insufficient participation, interaction, and shared responsibility for learning.

Student Teams Achievement Divisions (STAD) cooperative learning offers a relevant pedagogical response to these conditions. STAD combines class presentation, heterogeneous team learning, peer tutoring, individual assessment, individual improvement scores, and group recognition. Its structure integrates cooperation with individual accountability, requiring students to develop their own understanding while contributing to the learning of other team members

(Rusman et al., 2015; Herianto, 2025). In mathematics classrooms, such interaction can provide opportunities to explain ideas, compare solution strategies, identify conceptual errors, and obtain peer support. Group recognition may further strengthen students' responsibility for active participation in the learning process (Raysharie et al., 2023).

Previous research has provided substantial evidence supporting STAD in mathematics education. Gunawan and Nurtiyasari (2022) reported improved mathematics achievement following STAD implementation, while Marwah and Lestari (2023) identified improvements in both learning activities and outcomes. More recent studies similarly found favorable mathematics achievement, conceptual understanding, and classroom participation associated with STAD (Hanifah & Armiati, 2025; Saragih et al., 2025; Harahap et al., 2026). STAD has also been adapted to technology-supported environments, suggesting that the model remains relevant to contemporary mathematics instruction (Anugerah et al., 2026). Collectively, these findings suggest that its educational value extends beyond simply placing students into groups and instead depends on structured peer interaction, cooperation, and individual accountability.

However, the existing literature has predominantly focused on whether STAD improves learning outcomes, commonly through comparisons of achievement, mastery, or performance between treatment and comparison groups. Less attention has been devoted to how STAD implementation is systematically refined when its initial application does not produce optimal participation or learning outcomes. This distinction is important because the effectiveness of cooperative learning depends on the quality of group interaction, distribution of responsibility, functioning of peer tutors, and individual accountability rather than on procedural adoption of the model alone. Recent evidence also indicates considerable variation in STAD outcomes across instructional contexts, suggesting that implementation quality and learner characteristics may influence its effectiveness (Sukra et al., 2026).

This gap is particularly relevant to Classroom Action Research (CAR), in which reflection is expected to guide pedagogical improvement from one cycle to the next. Although previous classroom-based studies have documented increased achievement across STAD cycles, the relationship between problems identified during an initial cycle, subsequent corrective actions, and changes observed in the following cycle has not always been explicitly analyzed (Marwah & Lestari, 2023). Examining this process can provide more meaningful evidence about STAD as an instructional practice that is progressively refined through observation and reflection rather than merely implemented as a fixed sequence of activities.

The Pythagorean Theorem provides an appropriate context for such implementation because successful learning requires more than memorizing a mathematical relationship. Students must identify right triangles, determine relationships among their sides, extract relevant information, and apply the concept to problem-solving situations. Differences in students' academic readiness may result in some learners completing these processes independently while others require additional explanation and feedback. Heterogeneous grouping and peer tutoring within STAD can potentially accommodate these differences, provided that stronger students do not dominate group tasks and that each member assumes meaningful responsibility for learning.

Accordingly, the contribution of this study lies not simply in providing additional evidence regarding STAD but in examining its iterative pedagogical refinement across action-research cycles. Problems identified during Cycle I were used to modify Cycle II through stronger peer-tutoring roles, clearer individual responsibilities, more structured group interaction, and reinforced team recognition. The study therefore aimed to improve Grade 8A students' mathematics learning outcomes on the Pythagorean Theorem through STAD and to examine how reflective modifications to its implementation contributed to changes in learning across the two action cycles.

II. METHOD

This study employed Classroom Action Research (CAR) using the cyclical model of Kemmis and McTaggart, in which each cycle comprises planning, action, observation, and reflection (Dianarini et al., 2020; Hidayat & Nizar, 2021; Maulyda, 2020). The study was conducted during the first semester of the 2025/2026 academic year at Santo Yusup Pacet Junior High School and involved 35 students from Grade 8A. The research consisted of two cycles, each including two instructional meetings and one evaluation session. Each instructional meeting lasted 2 × 40 minutes. The findings from Cycle I were systematically reflected upon and used to modify the implementation of STAD in Cycle II.

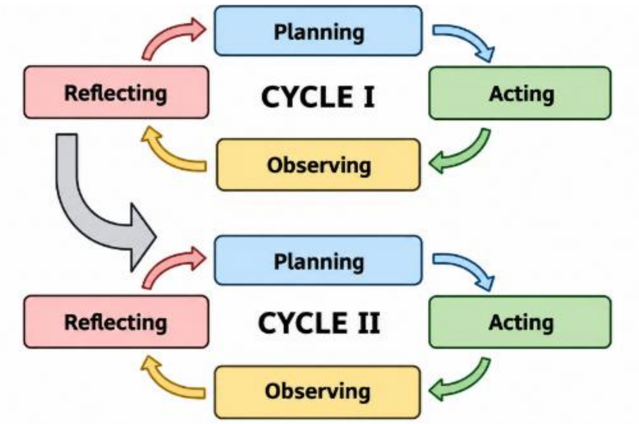

Figure 1. Classroom Action Research Cycle

The intervention followed the Student Teams Achievement Divisions (STAD) cooperative learning structure. Students were organized into six heterogeneous groups of five to six members based on academic ability and student characteristics. Instruction involved class presentation, heterogeneous group work, peer tutoring, individual quizzes, and group recognition (Rizzaludin, 2022). During group activities, students discussed the Pythagorean Theorem and supported one another in understanding concepts and solving problems, while individual assessments maintained personal accountability. The teacher facilitated the learning process, monitored group interaction, and provided recognition for group achievement. Based on reflection after Cycle I, the second cycle incorporated instructional refinements to address difficulties identified during the initial implementation.

Data were collected through achievement tests, classroom observations, and field notes. Initial mathematics achievement was obtained from a previous daily assessment and was used solely to describe the students' baseline learning condition rather than as an equivalent pretest on the Pythagorean Theorem. At the end of each action cycle, students completed a 10-item essay test assessing conceptual understanding of the Pythagorean Theorem, determination of side lengths in right triangles, and contextual problem solving. Classroom observations focused on students' participation, questioning, cooperation, and engagement during group activities, while field notes documented relevant events and implementation issues. The research instruments were reviewed prior to use to ensure their appropriateness for data collection (Jannah & Habiby, 2022, 2023).

Quantitative data were analyzed descriptively using mean achievement scores and classical mastery percentages, whereas observational and field-note data were examined qualitatively to identify changes in participation and the implementation of STAD across cycles. The action was considered successful when students' mean achievement improved across cycles and classical mastery reached at least 70%. Qualitative findings from each cycle were incorporated into the reflection process to identify implementation problems and determine corrective actions for the subsequent cycle. This iterative analysis allowed changes in learning outcomes to be interpreted alongside the pedagogical refinements made from Cycle I to Cycle II.

III. RESULTS AND DISCUSSION

A. Results

1. Initial Condition

Before the intervention, classroom observations and data from a previous mathematics assessment were examined to establish the students' initial learning condition. These scores represented general prior mathematics achievement rather than a pretest on the same Pythagorean Theorem content used during the intervention. Consequently, changes from the initial condition to the action cycles were interpreted as developments in learning achievement during the intervention rather than as direct pretest–posttest gains on identical content. The initial mean score was 58.29, with only 6 of 35 students (17.14%) achieving the Minimum Mastery Criterion.

Table 1. Students' Mathematics Achievement in the Initial Condition

Stage	Mastered	Not Mastered	Mean Score	Classical Mastery
Initial condition	6	29	58.29	17.14%

The initial findings indicated that most students had not achieved the expected level of mathematics mastery. Classroom observations also identified limited participation and peer interaction, providing the basis for implementing STAD as a classroom action.

2. Cycle I

Cycle I focused on investigating types of triangles using Pythagorean triples. During the planning stage, lesson modules, learning materials, instructional media, and assessment instruments were prepared. Students were organized into six heterogeneous groups of five to six members, considering differences in academic ability and student characteristics. STAD was implemented through six stages: communicating learning objectives and motivation, presenting information, organizing students into groups, facilitating team learning and peer tutoring, administering individual quizzes, and providing group recognition. Observations focused on participation in discussion, cooperation, and willingness to ask questions.

Table 2. Students' Mathematics Achievement in Cycle I

Stage	Mastered	Not Mastered	Mean Score	Classical Mastery
Cycle I	13	22	69.77	37.14%

Following Cycle I, the mean score reached 69.77, while classical mastery increased to 37.14%. Although achievement improved, the predetermined success criterion of 70% classical mastery had not yet been reached. Reflection indicated that several students were still adapting to cooperative learning and that responsibilities within the groups were not distributed optimally. Some students continued to depend on academically stronger peers rather than participating equally in team activities. These observations became the basis for instructional refinement in Cycle II.

3. Cycle II

Cycle II retained the STAD structure while introducing improvements based on the preceding reflection. Instruction focused on determining an unknown side of a right triangle using the Pythagorean Theorem. Before introducing the new material, the teacher reviewed essential concepts and exercises related to the Pythagorean Theorem and Pythagorean triples. Particular attention was given to strengthening peer-tutoring roles, clarifying individual responsibilities within each group, encouraging more active participation, and reinforcing group recognition. The six STAD stages were then implemented consistently throughout the learning process.

Table 3. Students' Mathematics Achievement in Cycle II

Stage	Mastered	Not Mastered	Mean Score	Classical Mastery
Cycle II	26	9	81.29	74.29%

Cycle II produced further improvement, with the mean score increasing to 81.29 and 26 of 35 students (74.29%) achieving mastery. Compared with Cycle I, the mean increased by 11.52 points, while classical mastery increased by 37.15 percentage points. The Cycle II mastery rate therefore exceeded the predetermined success criterion of 70%. Observational evidence also indicated stronger participation in group activities following the refinement of peer-tutoring roles, individual responsibilities, and group recognition.

Across the action-research process, the mean score progressed from 58.29 in the initial condition to 69.77 in Cycle I and 81.29 in Cycle II, while classical mastery increased from 17.14% to 37.14% and subsequently to 74.29%. Thus, the mean score in Cycle II was 23.00

points higher than the initial assessment, corresponding to a descriptive increase of approximately 39.46%, while classical mastery increased by 57.15 percentage points. Because the initial assessment did not measure exactly the same content as the cycle assessments, however, these changes should be interpreted as a pattern of improved mathematics achievement across the action-research process rather than as a direct gain score from equivalent measurements.

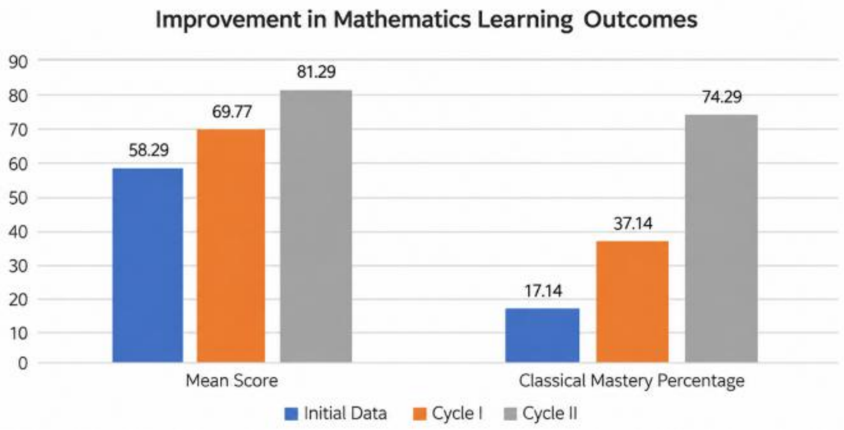

Figure 2. Changes in Students' Mathematics Achievement Across the Action-Research Cycles

The progression across the two cycles suggests that improvement occurred alongside the iterative refinement of STAD implementation. Cycle I revealed weaknesses in students' adaptation to cooperative work and the distribution of group responsibilities; Cycle II responded by strengthening peer tutoring, clarifying individual roles, and reinforcing team recognition. Following these modifications, both achievement and classroom participation improved, and the established classical mastery criterion was attained. Accordingly, the findings support the success of the classroom action within the studied setting while also showing that the improvement was associated not merely with the use of STAD itself, but with its systematic refinement through observation and reflection.

B. Discussion

The findings indicate a consistent improvement in students' mathematics achievement following the implementation and refinement of Student Teams Achievement Divisions (STAD). The mean score increased from 58.29 in the initial condition to 69.77 in Cycle I and 81.29 in Cycle II, while classical mastery progressed from 17.14% to 37.14% and 74.29%, respectively. Because the initial assessment represented general prior mathematics achievement rather than an equivalent pretest on the Pythagorean Theorem, these changes should be interpreted as a pattern of improved achievement throughout the action-research process rather than as a direct pretest–posttest effect. Nevertheless, the attainment of 74.29% classical mastery in Cycle II, exceeding the predetermined 70% criterion, demonstrates that the classroom action achieved its intended target.

The improvement can be understood in relation to the core structure of STAD, which combines heterogeneous group learning, peer tutoring, individual accountability, and group recognition. Through collaborative discussion, students had opportunities to explain mathematical ideas, compare solution procedures, ask questions, and receive assistance from peers before completing individual assessments. Such interactions can facilitate active construction of mathematical understanding while ensuring that achievement remains an individual responsibility. This interpretation is consistent with Rizzaludin (2022) and Khaira et al. (2021), who reported favorable learning outcomes associated with cooperative interaction and peer support. It is also supported by evidence emphasizing the contribution of communication, collaboration, active engagement, and learning independence to the quality of learning processes and outcomes (Kusuma et al., 2022; Nuvitalia et al., 2024).

More importantly, the findings illustrate the reflective and iterative nature of STAD implementation. Although achievement improved in Cycle I, classical mastery remained at only 37.14%, indicating that the initial implementation had not yet produced the expected outcome. Classroom observations revealed that students were still adapting to cooperative learning, responsibilities within teams were not sufficiently balanced, and some students continued to depend on more active or academically stronger peers. These findings demonstrate that simply organizing students into cooperative groups was insufficient; productive collaboration required clearer responsibilities and more structured peer interaction.

Reflection on these difficulties informed specific modifications in Cycle II, particularly strengthening peer-tutoring roles, clarifying individual responsibilities, and reinforcing group recognition. Following these adjustments, the mean score increased by 11.52 points, from 69.77 to 81.29, while classical mastery rose by 37.15 percentage points, from 37.14% to 74.29%. Observations also indicated greater participation in discussions, increased willingness to ask questions, and stronger peer support. Students with higher academic performance increasingly assisted their peers, while students experiencing difficulties appeared more willing to seek clarification within their groups. This pattern is consistent with the principle of STAD that cooperative success depends on the interaction between individual accountability and shared responsibility for team achievement.

Group recognition also appeared to strengthen students' engagement during Cycle II. Rather than functioning merely as an external reward, team recognition encouraged members to contribute to collective achievement while maintaining responsibility for their individual performance. This mechanism is consistent with the theoretical foundation of STAD, in which individual improvement and group achievement are deliberately interconnected. Thus, the improvement observed in Cycle II should not be attributed solely to repeated exposure to STAD, but should also be understood in relation to the pedagogical refinements introduced after reflection on Cycle I.

Overall, this study extends previous evidence on STAD by highlighting not only changes in mathematics achievement but also the process through which its classroom implementation was progressively improved. The findings suggest that STAD can support learning of the Pythagorean Theorem when heterogeneous grouping, peer tutoring, individual accountability, and group recognition are implemented coherently. However, because this Classroom Action Research involved a single class without a comparison group, the observed improvement cannot be attributed exclusively to STAD. The findings are therefore best interpreted as evidence that the iterative implementation and refinement of STAD was associated with improved achievement and classroom participation in the studied context, rather than as proof of its causal superiority over other instructional approaches.

IV. CONCLUSION

The implementation of Student Teams Achievement Divisions (STAD) across two Classroom Action Research cycles was associated with improved mathematics achievement among Grade 8A students at Santo Yusup Pacet Junior High School in learning the Pythagorean Theorem. The mean score increased from 69.77 in Cycle I to 81.29 in Cycle II, while classical mastery rose from 37.14% to 74.29%, exceeding the predetermined success criterion of 70%. The initial score of 58.29 with 17.14% mastery served only as a general description of students' prior mathematics achievement and was not an equivalent pretest on the intervention content. Importantly, the improvement in Cycle II coincided with reflective modifications to STAD, particularly stronger peer tutoring, clearer individual responsibilities, more structured group interaction, and reinforced team recognition. These findings highlight the importance of adaptive and reflective STAD implementation, rather than procedural application alone, in supporting mathematics learning. Nevertheless, because the study involved a single class within a Classroom Action Research design, the findings are context-specific and should not be generalized beyond comparable instructional settings without further investigation.

CONFLICT OF INTEREST

The authors declare that no competing financial, institutional, or personal interests influenced the conduct of this research or the presentation of its findings.

AUTHOR CONTRIBUTIONS

Yohanes Bayu Prasetyo *contributed to the identification of the classroom problem, preparation and implementation of the STAD intervention, data collection, classroom observation, analysis of learning outcomes, reflection across action-research cycles, and preparation of the initial manuscript.* ***Greoria Ariyanti*** *contributed to the research methodology, academic supervision, interpretation of the findings, evaluation of the action-research process, and substantive review and revision of the manuscript. Both authors participated in refining the manuscript, approved the final version, and accept responsibility for the integrity of the work.*

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

Generative AI and AI-assisted tools were used exclusively to support language editing and improve the clarity and academic readability of the manuscript. They were not used to generate research data, conduct data analysis, determine the results, or formulate the scientific conclusions of the study. All AI-assisted revisions were critically reviewed and verified by the authors, who retain full responsibility for the accuracy, originality, and integrity of the final manuscript.

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