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Comparative Effectiveness of Student Team Achievement Division and Team Assisted Instruction on Grade 10 Students' Performance in Polynomial Functions

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ABSTRACT

This study examined the comparative effectiveness of Student Team Achievement Division (STAD) and Team Assisted Instruction (TAI) in improving Grade 10 students' performance in illustrating polynomial functions and writing polynomials in standard form. Grounded in cooperative learning theory, a quantitative quasi-experimental counterbalanced repeated-measures design was employed involving 20 Grade 10 students from a public secondary school during the 2024–2025 academic year. Descriptive statistics and paired-samples t-tests were used to analyze post-test scores, while structured classroom observations assessed learning behaviors. Results indicated that both STAD and TAI produced high levels of mathematics achievement. Although TAI yielded slightly higher mean scores, the differences were not statistically significant at the 0.05 level, with only small effect sizes observed. Behavioral findings demonstrated consistently high levels of participation, collaboration, attentiveness, and persistence under both instructional conditions. The results suggest that shared cooperative learning mechanisms, positive interdependence, individual accountability, peer explanation, and scaffolding, may exert a stronger influence on achievement than procedural differences between models. Despite limitations related to sample size and the absence of a pre-test, the study provides context-specific evidence supporting the effectiveness of structured cooperative learning in secondary algebra instruction.

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INTRODUCTION

Mathematics achievement in developing countries continues to present significant challenges, shaped by interconnected motivational, emotional, and instructional factors. Among these, student motivation plays a decisive role in determining how learners approach mathematical tasks and persist through difficulties. Higher levels of intrinsic motivation are consistently associated with improved engagement, cognitive development, and stronger learning outcomes in mathematics (Barrera, 2024; Kelkar, 2025). Conversely, mathematics anxiety—characterized by tension and apprehension toward mathematical activities—can substantially hinder performance and reduce students' willingness to participate (Galano et al., 2025; Khamouja et al., 2023; Siswanto et al., 2025). In many developing contexts, these psychological factors are further compounded by limitations in instructional quality, including insufficient teacher preparation and constrained learning resources (Mollel, 2025; Tsegaye, 2019; Wartenberg et al., 2023). When instruction lacks structure, differentiation, and interactive opportunities, students are less likely to develop deep conceptual understanding (Sandy, 2025; Zahra et al., 2025).

These conditions highlight the central role of student engagement as a mediator between instructional practices and mathematics achievement. Engagement encompasses multiple dimensions—participation, attention, academic interaction, and persistence—each contributing uniquely to learning outcomes. Active participation enables students to ask questions, contribute to discussions, and collaborate with peers, thereby promoting deeper conceptual processing (Doménech-Betoret et al., 2019; Rhoads et al., 2017). Sustained attention is equally essential, as distractions and reduced focus negatively affect comprehension and retention (Lim et al., 2016). Academic interaction enhances reasoning processes through dialogue and explanation, strengthening students' ability to articulate and refine mathematical ideas (Khamouja et al., 2023; Mweemba & Allida, 2021). Furthermore, persistence allows learners to confront challenging tasks with resilience, particularly when classroom practices cultivate a growth-oriented mindset (Khamouja et al., 2023; Rhoads et al., 2017).

Empirical findings demonstrate that these engagement dimensions are strongly associated with improved mathematics performance. Participation and academic interaction, in particular, show substantial positive effects on problem-solving ability and conceptual mastery (Chiaramonte, 2025; Ocampo Buitrago et al., 2025). When students are actively engaged, they tend to experience reduced anxiety, strengthened motivation, and greater confidence in tackling complex problems. Thus, low mathematics achievement can be understood not merely as a cognitive deficit but as the outcome of intertwined motivational, emotional, and instructional shortcomings. Addressing these challenges requires pedagogical strategies that enhance instructional quality while deliberately fostering meaningful student engagement.

In response to these concerns, cooperative learning has emerged as a research-supported alternative to traditional teacher-centered instruction. Unlike conventional approaches that emphasize passive reception of information, cooperative learning promotes structured collaboration and shared academic responsibility. Its effectiveness is grounded in several theoretical mechanisms. Positive interdependence encourages students to perceive their success as linked to that of their peers, strengthening collective commitment to learning (Acharya, 2023; Ridwan & Hadi, 2022). Individual accountability ensures that each learner remains responsible for mastering the material, thereby preventing social loafing (Ridwan & Hadi, 2022). Peer explanation provides opportunities for students to verbalize reasoning processes, reinforcing understanding for both the explainer and the listener (Atteh et al., 2020). In addition, scaffolding within collaborative groups enables more knowledgeable peers to support others, facilitating gradual cognitive development and comprehension of complex mathematical concepts (Atteh et al., 2020; Ridwan & Hadi, 2022). Empirical studies consistently report that cooperative learning leads to higher mathematics achievement and more positive attitudes compared to traditional instruction (Acharya, 2023; Karali & Aydemir, 2018; Tshering & Dorji, 2022).

Among cooperative learning models, Student Team Achievement Division (STAD) and Team Assisted Instruction (TAI) are widely implemented in mathematics classrooms. STAD follows a structured sequence in which teachers introduce concepts, students practice collaboratively in teams, and individual assessments contribute to group recognition, thereby balancing cooperation with measurable accountability (Ridwan & Hadi, 2022; Tshering & Dorji, 2022). In contrast, TAI combines cooperative grouping with individualized instructional materials and teacher guidance, offering greater flexibility for mixed-ability classrooms and supporting algebraic learning through differentiated assistance (Ridwan & Hadi, 2022; Tshering & Dorji, 2022). Comparative research suggests that TAI may demonstrate stronger outcomes in heterogeneous classrooms requiring varied instructional support, whereas STAD may be particularly effective in environments emphasizing structured performance and team-based incentives (Ridwan & Hadi, 2022; Tshering & Dorji, 2022). Despite substantial international evidence supporting both models, limited localized research directly compares their effectiveness within specific secondary-level algebra topics.

Addressing this gap constitutes the primary contribution and novelty of the present study. While prior investigations have confirmed the general benefits of cooperative learning, few studies have systematically compared STAD and TAI within the same cohort of Grade 10 students focusing specifically on illustrating polynomial functions and writing polynomials in standard form. This study therefore aims to determine the effectiveness of these two innovative cooperative learning strategies in improving students' mathematics performance and learning behaviors. Specifically, it seeks to (1) determine the level of students' mathematics performance after the use of STAD and TAI, (2) examine whether a significant difference exists between students' mean post-test scores under the two strategies, and (3) describe the observed learning behaviors exhibited during the implementation of each strategy. By integrating performance outcomes with behavioral observations, this research provides context-sensitive empirical evidence to inform instructional decisionmaking and contributes to the broader discourse on effective cooperative learning practices in secondary mathematics education.

METHOD

This study employed a quantitative quasi-experimental design using a counterbalanced repeated-measures approach. The same group of Grade 10 students (n = 20) was exposed to both cooperative learning strategies—Student Team Achievement Division (STAD) and Team Assisted Instruction (TAI)—across two instructional phases covering comparable algebraic competencies (illustrating polynomial functions and writing polynomials in standard form). To minimize order effects, the implementation sequence of the two strategies was counterbalanced across learning sessions. This design allowed for within-group comparison while controlling for inter-group variability, thereby strengthening internal consistency despite the limited sample size.

Although a separate pre-test was not administered, baseline equivalence was inferred from prior academic records and comparable prerequisite competencies established before the intervention. Both instructional phases were delivered by the same teacher-researcher to ensure consistency in content coverage, time allocation, and assessment procedures. The primary objective was not to measure long-term growth but to compare the relative effectiveness of two structured cooperative learning strategies under controlled classroom conditions.

Participants and Context

The participants were 20 Grade 10–Agila students from Marc Ysrael B. Bernos Memorial National High School during the 2024–2025 academic year. The class was selected through purposive sampling based on accessibility and alignment with the algebraic competencies under investigation. While the sample size is relatively small, it reflects the intact classroom population and is appropriate for within-subject statistical comparison. The study was conducted during regular mathematics instructional hours to preserve ecological validity.

Instructional Procedures

Two cooperative learning strategies were implemented:

1. Student Team Achievement Division (STAD): The teacher introduced the lesson, after which students worked in heterogeneous teams to complete structured practice activities. Individual quizzes were administered, and team recognition was based on aggregated improvement scores. This structure emphasized positive interdependence and individual accountability.
2. Team Assisted Instruction (TAI): Students were organized into mixed-ability groups and provided with individualized learning materials. Peer assistance and teacher scaffolding were integrated throughout the learning process. Mastery checks were conducted to ensure comprehension before progressing to subsequent tasks.

Both strategies were implemented over equivalent instructional durations and covered parallel content to ensure comparability. Classroom observations were conducted systematically during each implementation phase.

Research Instruments

Student performance was measured using a researcher-developed 50-item post-test covering two domains: (1) illustrating polynomial functions (25 items) and (2) writing polynomials in standard form (25 items). The instrument underwent content validation by three subject-matter experts to ensure alignment with curriculum standards and learning objectives. Revisions were made based on expert feedback to enhance clarity and content representativeness.

Student learning behaviors were assessed using a 20-indicator observation checklist adapted from established cooperative learning observation frameworks. The checklist measured dimensions such as participation, persistence, collaboration, attentiveness, and responsiveness to feedback. The instrument's validity was examined through expert review prior to administration.

Data Analysis

Descriptive statistics, including mean and standard deviation, were computed to determine the level of mathematics performance under each strategy. Inferential analysis was conducted using paired-samples t-tests to examine whether significant differences existed between students' mean scores under STAD and TAI. Statistical significance was evaluated at the 0.05 alpha level. Effect sizes (Cohen's d) were calculated to determine the magnitude of observed differences. Assumptions of normality were assessed prior to conducting parametric tests.

Weighted means were used to interpret observed behavioral indicators according to predetermined descriptive scales. Data were analyzed systematically to ensure consistency, and statistical reporting was aligned with standard quantitative research conventions.

Ethical Considerations

Permission to conduct the study was obtained from the school administration. Participation was limited to regular classroom activities, and no student was disadvantaged by the instructional interventions. Confidentiality of student data was maintained throughout the analysis and reporting process.

RESULTS

This section presents the statistical findings of the study in alignment with the revised quasi-experimental counterbalanced repeated-measures design. Descriptive statistics and paired-samples t-tests were employed to examine students' mathematics performance under the Student Team Achievement Division (STAD) and Team Assisted Instruction (TAI) strategies. Assumptions of normality were examined prior to inferential testing and were found to be acceptable for parametric analysis.

Descriptive Statistics of Students' Performance

Under the STAD strategy, students obtained a mean score of 19.10 (SD = 2.31) in illustrating polynomial functions and 20.05 (SD = 2.18) in writing polynomials in standard form, resulting in an overall mean score of 39.15 (SD = 4.12). Based on the predetermined performance scale, these results correspond to a Very Satisfactory level of performance (Table 1).

Table 1. Level of Mathematics Performance of the Students after the use of the STAD Strategy

Topics	No. of items	Mean	Descriptive Rating (DR)
Illustrating Polynomials	25	19.10	Very Satisfactory
Writing Polynomials into Standard Form	25	20.05	Excellent
Total	50	39.15	Very Satisfactory

Under the TAI strategy, students achieved a mean score of 19.90 (SD = 2.24) in illustrating polynomials and 20.15 (SD = 2.06) in writing polynomials in standard form, with an overall mean score of 40.05 (SD = 3.95). These results correspond to an Excellent level of performance (Table 2).

Table 2. Level of Mathematics Performance of the Students after the use of the TAI Strategy

Topics	No. of items	Mean	Descriptive Rating (DR)
Illustrating Polynomials	25	19.90	Very Satisfactory
Writing Polynomials into Standard Form	25	20.15	Excellent
Total	50	40.05	Excellent

Although TAI yielded slightly higher mean scores than STAD across domains, both strategies demonstrated high levels of academic performance, suggesting that structured cooperative learning positively influenced students' understanding of algebraic concepts.

Inferential Analysis: Paired-Samples t-Test

To determine whether a statistically significant difference existed between students' performance under STAD and TAI, paired-samples t-tests were conducted for each learning domain and for overall performance (Table 3).

Table 3. t-Test of Difference between the Students' Performance Grouped by Strategies

Topics	Computed-t	t-crit	t-prob	p-value	Decision
Illustrating Polynomials	1.49	1.73	0.07	P<0.05	Not Significant

Writing Polynomials into Standard Form	0.19	1.73	0.42	P<0.05	Not Significant
Total	1.27	1.73	0.11	P<0.05	Not Significant

For illustrating polynomial functions, the difference between STAD (M = 19.10, SD = 2.31) and TAI (M = 19.90, SD = 2.24) was not statistically significant, t(19) = 1.49, p = .07. The effect size was small (Cohen's d = 0.33), indicating a modest practical difference.

For writing polynomials in standard form, the difference between STAD (M = 20.05, SD = 2.18) and TAI (M = 20.15, SD = 2.06) was also not statistically significant, t(19) = 0.19, p = .42. The calculated effect size was negligible (Cohen's d = 0.04).

In terms of overall mathematics performance, the comparison between STAD (M = 39.15, SD = 4.12) and TAI (M = 40.05, SD = 3.95) revealed no statistically significant difference, t(19) = 1.27, p = .11, with a small effect size (Cohen's d = 0.28).

Since all obtained p-values were greater than the 0.05 significance level, the null hypothesis was not rejected. These findings indicate that there is no statistically significant difference in students' mathematics performance between the two cooperative learning strategies. However, both strategies demonstrated positive academic outcomes, reinforcing their instructional value.

Behavioral Observation Results

Behavioral observations were analyzed using weighted means based on a five-point descriptive scale. Under the STAD implementation, students obtained an overall behavioral mean of 4.71 (Always), indicating consistently high levels of participation, collaboration, attentiveness, and task completion. Under TAI, the overall behavioral mean was 4.47 (Always), reflecting similarly positive engagement patterns, though slightly lower in persistence and voluntary participation.

The consistently high behavioral ratings across both strategies support the quantitative performance results, suggesting that cooperative learning structures promoted active engagement and collaborative interaction in mathematics instruction.

Table 4. Observed Behaviors of the Students on the Use of Strategies

Indicators	Mean Scores	
	STAD	TAI
1. Pays attention in class	4.90	4.60
2. Work well with other students	4.90	4.60
3. Attempts to do his/her work thoroughly and well, rather than just trying to get by	5.00	4.50
4. Is actively engaged and always on the move	4.90	4.70
5. Participate actively in discussion	4.20	4.50
6. Completes assigned task	5.00	4.90
7. Responds well to constructive feedback and support	4.70	4.80
8. Is enthusiastic and enjoys interacting with peers	4.60	4.70
9. Is persistent when confronted with difficult problems	4.20	4.10
10. Benefits from extra guidance to stay on track in class	5.00	4.40
11. Takes time to observe and process before engaging	4.80	4.70
12. Approaches new assignments with sincere effort	4.70	4.40
13. Ask questions to get more information	4.30	4.20
14. Is social and enjoys collaborating with peers.	4.30	4.20
15. Thrives with support and encouragement to stay on task	4.70	4.00
16. Tries to finish assignments even when they are difficult	5.00	4.70
17. Raise his/her hand to answer a question or volunteer information	4.20	4.10
18. Learns best with encouragement and strategies for overcoming challenges	5.00	4.40
19. Gather information related to the problem and form new ideas	4.70	4.50
20. Analyze and clarify the situation in learning	5.00	4.50

Total	4.71	4.47

Overall, the statistical findings demonstrate that both STAD and TAI are effective cooperative learning strategies for improving students' understanding of polynomial concepts. While TAI showed marginally higher mean scores, the differences were not statistically significant. These results suggest that both peer-driven and teacher-assisted cooperative learning structures can yield comparable academic benefits when implemented systematically.

DISCUSSION

The present study examined the comparative effectiveness of Student Team Achievement Division (STAD) and Team Assisted Instruction (TAI) in improving Grade 10 students' performance in illustrating polynomial functions and writing polynomials in standard form. The findings revealed that both strategies resulted in high levels of academic achievement, with no statistically significant difference between them. This outcome is consistent with prior research indicating that various cooperative learning models often produce comparable gains in mathematics performance when implemented systematically (Ridwan & Hadi, 2022; Tshering & Dorji, 2022). Although some studies report contextual advantages of one model over another, the absence of significant differences in this study suggests that the shared cooperative principles embedded in both STAD and TAI may play a more decisive role than their procedural distinctions.

The comparable effectiveness of STAD and TAI can be interpreted through their common theoretical foundations. Both models operationalize positive interdependence and individual accountability, which are central to successful cooperative learning environments (Acharya, 2023; Ridwan & Hadi, 2022). Additionally, opportunities for peer explanation and collaborative problem-solving likely strengthened students' conceptual understanding of algebraic procedures, as supported by Atteh et al. (2020). The scaffolding processes inherent in cooperative group work, whether peer-driven as in STAD or teacher-assisted as in TAI, may have facilitated gradual mastery of polynomial concepts. These mechanisms align with broader findings that cooperative learning enhances deeper mathematical reasoning compared to traditional teacher-centered instruction (Karali & Aydemir, 2018; Tshering & Dorji, 2022).

Behavioral observations further reinforce the quantitative results. Students under both instructional conditions demonstrated consistently high levels of participation, collaboration, attentiveness, and task persistence. This pattern supports literature emphasizing the strong relationship between student engagement and mathematics achievement (Chiaramonte, 2025; Doménech-Betoret et al., 2019). Participation and academic interaction, in particular, are known to contribute to improved conceptual understanding and problem-solving ability (Ocampo Buitrago et al., 2025). The findings suggest that cooperative structures not only improved academic performance but also fostered positive classroom behaviors that are essential for sustained learning. Thus, engagement appears to function as a mediating variable linking cooperative instructional strategies with improved mathematics outcomes.

The absence of statistically significant differences between STAD and TAI may also be influenced by contextual factors. The study was conducted within a single intact class of 20 students, using a counterbalanced repeated-measures design to ensure instructional consistency. The relatively small sample size may have limited statistical power, potentially reducing the likelihood of detecting subtle differences between strategies. Moreover, both interventions were implemented by the same teacher within a controlled classroom environment, which may have minimized variability attributable to instructional delivery. It is also possible that the algebraic topics selected—illustrating polynomial functions and writing polynomials in standard form—were equally well supported by both cooperative structures, thereby contributing to the similarity of outcomes. Such contextual considerations highlight the importance of interpreting non-significant findings with methodological awareness rather than assuming equivalence without reflection.

Despite these limitations, the study contributes context-sensitive evidence to the literature on cooperative learning in secondary mathematics education. While international research has widely documented the effectiveness of STAD and TAI, localized comparative investigations in Philippine secondary classrooms remain limited. By examining both performance outcomes and observed learning behaviors within the same cohort, this study extends existing scholarship and provides practical insights for mathematics educators. The findings imply that teachers may select either peer-driven (STAD) or teacher-assisted (TAI) cooperative structures depending on classroom needs, resource availability, and student characteristics, without compromising academic effectiveness. Future research involving larger samples, multiple schools, and pre-test–post-test designs may further clarify conditions under which one model demonstrates superior impact.

CONCLUSION

This study investigated the comparative effectiveness of two cooperative learning strategies, i.e., Student Team Achievement Division (STAD) and Team Assisted Instruction (TAI) in improving Grade 10 students' performance in illustrating polynomial functions and writing polynomials in standard form. Consistent with the statistical findings and behavioral observations, both strategies resulted in high levels of academic achievement and positive learning behaviors. Although TAI produced slightly higher mean scores, the differences between the two strategies were not statistically significant. These findings indicate that both peer-driven and teacher-assisted cooperative structures can effectively support students' conceptual understanding of algebraic topics when implemented systematically.

The results suggest that the shared theoretical foundations of cooperative learning, positive interdependence, individual accountability, peer explanation, and structured scaffolding, may exert a stronger influence on mathematics performance than procedural variations between specific models. Moreover, the consistently high levels of participation, collaboration, and persistence observed during implementation reinforce the role of student engagement as a critical mechanism underlying improved achievement. Thus, cooperative learning not only enhances academic outcomes but also cultivates constructive classroom behaviors that contribute to sustained learning.

While the study was limited to a single intact class and did not include a pre-test measure, it provides context-specific empirical evidence relevant to secondary mathematics instruction in the Philippine setting. The findings imply that educators may flexibly adopt either STAD or TAI depending on classroom characteristics, available resources, and instructional preferences without compromising effectiveness. Future studies involving larger and more diverse samples, as well as longitudinal or pre-test–post-test designs, are recommended to further examine differential impacts and strengthen generalizability. Overall, this research contributes to the growing body of literature affirming the instructional value of cooperative learning in promoting meaningful and engaged mathematics learning.

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