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The Effect of Cooperative Small-Group Instruction on Fifth-Grade Students' Mathematics Engagement

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ABSTRACT

This study examined the effect of cooperative small-group instruction on fifth-grade students' engagement in mathematics. The research was conducted in a public school with 44 students across two classes, comprising an experimental group (n = 26) and a control group (n = 18) from similar socioeconomic backgrounds. Over five weeks, the experimental group received instruction on the Categorical Data Distributions unit through structured cooperative learning activities using the *Student Team Achievement Divisions* technique, while the control group followed traditional lecture-based instruction with limited opportunities for collaboration. Engagement was measured with the Mathematics Engagement Scale, administered as pre- and post-tests. Students were classified as low engagement (the lowest 30%) or moderate/high engagement (top 70%) based on pre-test scores. ANCOVA analyses, controlling for pre-test scores, confirmed normality and homogeneity assumptions. Findings indicated that the experimental group reported significantly higher engagement than the control group ($F(1, 41) = 13.67$, $p < .05$, $\eta^2 = .25$), representing a moderate effect size. Subgroup analyses further revealed that low-engagement students in the experimental group outperformed both low- and moderate/high-engagement students in the control group, while moderate/high-engagement students also showed notable gains ($F(3, 39) = 5.32$, $p = .004$, $\eta^2 = .29$). These results highlight the inclusive impact of cooperative learning, particularly in supporting initially disengaged students by fostering a more participatory classroom climate. The findings suggest that students with low participation levels should be identified early and supported through group work, and that lesson content should be designed around cooperative learning strategies.

İşbirlikli Küçük Grup Öğretiminin Beşinci Sınıf Öğrencilerinin Matematik Dersine Katılımına Etkisi

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ÖZET

Bu araştırma, işbirlikli öğrenme temelli küçük grup öğretiminin beşinci sınıf öğrencilerinin matematik dersine katılım düzeyleri üzerindeki etkisini incelemeyi amaçlamaktadır. Bir devlet okulunda yürütülen çalışma, deney (n=26) ve kontrol (n=18) olmak üzere iki sınıftan toplam 44 öğrenciyi kapsamaktadır. Beş hafta süresince deney grubu, "Kategorik Veri Dağılımları" ünitesine yönelik öğrenci merkezli işbirlikli etkinliklere katılırken; kontrol grubu, işbirliği fırsatlarının sınırlı olduğu geleneksel ders anlatımıyla öğrenim görmüştür. Katılım düzeyleri, geçerliği kanıtlanmış Matematik Dersi Katılım Ölçeği aracılığıyla ön test ve son test şeklinde ölçülmüştür. Kovaryans analizi (ANCOVA) sonuçları, deney grubundaki öğrencilerin kontrol grubuna göre anlamlı biçimde daha yüksek katılım sergilediğini göstermiştir ($F(1,41)=13.67$, $p<.05$, $\eta^2=.25$). Alt grup analizlerinde ise, başlangıçta düşük katılım düzeyine sahip öğrencilerin deney grubunda belirgin ilerleme kaydettiği ve akranlarını geçtiği; orta/yüksek katılım düzeyindeki öğrencilerin de kontrol grubuna kıyasla daha fazla gelişim gösterdiği bulunmuştur ($F(3,39)=5.32$, $p=.004$, $\eta^2=.29$). Bulgular, işbirlikli öğrenmenin özellikle düşük katılım gösteren öğrenciler için kapsayıcı ve destekleyici bir ortam sağlayarak matematik dersine katılımı artırdığını ortaya koymaktadır. Araştırma sonuçları, düşük katılım düzeyine sahip öğrencilerin erken dönemde belirlenip grup çalışmalarıyla desteklenmesi ve ders içeriklerinin işbirlikli öğrenme stratejilerine dayalı olarak hazırlanması gerektiğini önermektedir.

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INTRODUCTION

Education today is increasingly understood as a process that extends beyond the transmission of knowledge, encompassing the holistic development of learners. It has been widely recognized that focusing solely on students' cognitive skills is inadequate for meeting both individual developmental needs and labor market expectations (OECD, 2021). This recognition has made it inevitable to reconsider fundamental questions such as "How should the learning process be structured?" Learning is not merely the acquisition of knowledge but a process of existing in the world, grounded in socially oriented, language-based meanings that enable individuals to grow and transform (Jarvis, 2006). At its core, therefore, learning entails not only knowledge and skills, but also the systematic interpretation of learners' ideas, actions, interactions, and emotions.

Aligned with this view, the primary aim of contemporary education extends beyond the transmission of academic knowledge to cultivating individuals who can adapt to rapidly changing global conditions, think critically and independently, assume responsibility, and apply their knowledge throughout their lives (Demirel, 2011). Accordingly, research emphasizes that effective and lasting learning occurs when students take active roles in constructing meaning. This learner-centered orientation has brought increasing attention to pedagogical approaches that emphasize collaboration, interaction, and shared responsibility, with cooperative learning standing out as a particularly influential and effective model (Açıkgöz, 2003; Ekinci, 2011). Based on that, we aimed to implement one of the effective small group instruction techniques, Student-Team-Achievement-Division, in 5th-grade math classes to foster engagement and peer collaboration.

Cooperative Learning in Modern Education

The history of cooperative learning dates back many centuries. Evidence suggests that, for a long time, teachers have encouraged students to engage in group projects, discussions, peer teaching, and various other forms of group work (Johnson & Johnson, 1999). In earlier periods, however, these practices were often implemented in an unstructured and haphazard manner, lacking systematic pedagogical foundations. Since the 1970s, however, significant developments have transformed these previously informal practices into structured approaches grounded in various theoretical perspectives (Yang, 2023). Among these are social interdependence theory (Lewin; Deutsch), cognitive development theory (Piaget; Vygotsky), and behaviorist learning theory (Skinner; Bandura). The field has also been enriched by contributions from humanist educators and scholars of literature and philosophy (e.g., Bruffee), as well as social psychologists and STEM educators who systematically advanced cooperative learning research and practice (e.g., Johnson & Johnson; Slavin). As a result, specific cooperative learning strategies have been designed and implemented in a variety of educational settings, offering theoretical and practical frameworks for their application (Ekinci, 2011).

The concept of cooperative learning has been defined and labeled in various ways in Turkish literature, including işbirlikli öğrenme (collaborative learning), kubaşık öğrenme (reciprocal learning), and "work group," "peer learning," or "team learning" in international contexts (Gömleksiz, 1993; Sönmez, 2008). Despite differences in terminology, these definitions converge on a common principle: students work in small, heterogeneous groups to pursue shared academic goals, while simultaneously supporting one another's learning (Açıkgöz, 2003; Delen, 1998; Ekinci, 2011). Unlike traditional group work, cooperative learning requires structured interaction, equal participation, positive interdependence, and individual accountability, ensuring that each student contributes actively to group success (Sharan & Sharan, 2021).

Slavin (1995) provided multiple reasons for the widespread use of cooperative learning in educational settings, emphasizing its potential to strengthen social relationships, improve self-esteem, promote the inclusion of students from different ability groups, and promote problem-solving and sharing skills. Additionally, classrooms organized around cooperative learning become more heterogeneous, encouraging students from different ethnic and cultural backgrounds, as well as students with disabilities, to establish positive peer relationships. Crucially, learning becomes more accessible and meaningful through the social, cultural, and interpersonal interactions fostered in these settings. Similarly, Ekinci (2011) identified several pedagogical reasons for using cooperative learning in education. These include: (a) increasing student achievement; (b) developing higher-order thinking skills; (c) fostering self-esteem; (d) nurturing positive attitudes towards school and specific subjects; and (e) equipping students with essential social skills. Together, these outcomes demonstrate that cooperative learning is a comprehensive educational approach that combines the cognitive, social, and emotional development of students, rather than just an instructional technique. Importantly, research has shown that cooperative learning can be successfully implemented in large classrooms, countering the misconception that class size is a limiting factor (Aksoy & Doymuş, 2011). Indeed, the method provides opportunities for all students to participate actively, ask and answer questions, and express their opinions, even in overcrowded learning environments.

However, it is important to recognize that not all group work can be classified as cooperative learning. Simply placing students into groups and instructing them to work together does not guarantee genuine collaboration. The dual purpose of cooperative learning is to support students in achieving academic success while enabling them to develop essential social and interpersonal skills (Arends, 2000). This distinction highlights the importance of intentional design, structured interaction, and clear objectives in transforming group work into authentic collaborative learning experiences.

The effectiveness of cooperative learning is contingent upon adherence to certain core principles. These include positive interdependence, where students perceive their success as tied to the collective success of the group; individual accountability, which ensures that each learner's contribution is identifiable; face-to-face interaction, encouraging direct exchange of ideas and feedback; the development of social skills, such as leadership, communication, trust, and conflict resolution; and group processing, which involves reflecting on group performance to improve future collaboration (Çolak, 2006; Yeşilyurt, 2009). Among these, positive interdependence is particularly critical, as it motivates students to combine efforts, generate synergy, and ensure mutual responsibility for learning outcomes (Johnson & Johnson, 2005). Teachers play a pivotal role in this process by guiding group dynamics, facilitating cooperation, and creating an environment in which trust, empathy, and effective communication can flourish (Doymuş et al., 2005).

Small Group Learning Techniques in Cooperative Learning

Within the framework of cooperative learning, a wide range of instructional techniques has been developed, reflecting the fact that this approach is not a single method but rather a comprehensive system that integrates multiple strategies. The most well-known small-group learning techniques, such as "*Jigsaw, Learning Together, Think-Pair-Share, Student-Team-Achievement-Division, the Three-Step Interview, Teams-Games-Tournaments, Team-Accelerated Instruction, Group Investigation and Constructive Controversy,*" were invented by researchers specializing in cooperative learning (Yang, 2023). While all techniques are grounded in the core principles of cooperative learning—such as positive interdependence, individual accountability, face-to-face interaction, social skills, and group processing—they vary in how tasks are structured, how groups function, whether intergroup competition is incorporated, and the types of rewards utilized (Johnson & Johnson, 1999).

A substantial body of research has examined the effects of cooperative learning across different subject areas. For instance, Akar and Doymuş (2015), drawing on data from 316 students and 44 science teachers, compared cooperative strategies such as "learning together" and the "student teams achievement divisions" (STAD) technique with traditional instruction. The findings indicated that students taught with cooperative methods achieved significantly higher academic performance than those in the control group. Similarly, Arısoy and Tarım (2013) investigated the impact of cooperative learning in mathematics by employing the STAD and team-game-tournament (TGT) techniques. Their results demonstrated that while TGT produced greater gains in academic achievement, STAD was more effective in promoting retention.

In their study, Zakaria et al. (2010) compared cooperative learning with traditional methods among 82 lower-secondary students (aged around 13). Using the STAD technique with 44 experimental and 38 control group students, the study showed that cooperative learning significantly improved both mathematics achievement and students' attitudes toward the subject. The authors emphasized the importance of incorporating more student-centered approaches and recommended that teachers integrate cooperative learning strategies into their practice.

Building on these individual studies, Capar and Tarim (2015) conducted a meta-analysis of 26 investigations published between 1988 and 2010 that compared cooperative learning with conventional methods in mathematics. Covering studies identified in databases such as ProQuest, EBSCO, and ERIC, their synthesis revealed a medium positive effect of cooperative learning on academic achievement and a small but significant positive effect on attitudes toward mathematics. Overall, the evidence suggests that cooperative learning strategies are more effective than traditional methods in enhancing both performance and dispositions toward mathematics.

The Aim of the Current Study

Building on this literature, the present study examines the effects of cooperative small-group instruction on fifth-grade students' engagement in mathematics classes. We utilized the "Student-team-achievement-division" technique in this study. Student-Team-Achievement-Division (STAD) operates on the principles of group rewards, individual responsibility, and equal opportunities for success. In this technique, teams are recognized when they meet predetermined performance standards, with individual improvements contributing to collective success and motivational reinforcement provided through certificates or other incentives (Çolak, 2006). Once established, the technique unfolds through a four-step cycle: teach, team study, test, and recognition. This cyclical process ensures that students not only learn content but also actively engage with one another to reinforce understanding and accountability within their groups. According to Özden (1998), the implementation of STAD can be articulated in six structured phases:

- Formation of heterogeneous student groups.
- Assignment of the learning unit to the group.
- Determination of the specific group activity to be undertaken.
- Administration of an individual test following group work, requiring each student to respond independently.
- Ranking students based on their individual test scores.
- Awarding group recognition based on the collective points accumulated from individual performances.

This scoring system, which rewards students according to their contribution to the group's total achievement, enhances group dynamics and fosters motivation. It ensures that every member's success directly benefits the team, thereby encouraging cooperation and sustained engagement. Importantly, groups are restructured every five to six weeks, offering new opportunities for lower-achieving students to succeed and enabling learners to collaborate with a broader range of peers (Ekinci, 2011).

Specifically, our study investigates whether such instructional practices enhance overall engagement compared to traditional instruction, and whether the impact varies across students with different baseline engagement levels.

Accordingly, the study addresses the following research questions:

1. Do cooperative small-group instructional practices significantly improve fifth-grade students' engagement in mathematics compared to traditional teaching methods?
2. Does the effect of cooperative small-group instruction on mathematics engagement differ between students with initially low engagement and those with medium-to-high engagement levels?

METHOD

Research Design

This study was conducted using a quasi-experimental design, one of the quantitative research approaches. Quantitative research aims to examine relationships between dependent and independent variables in order to test theoretical assumptions (Creswell, 2017). In this study, the dependent variable was defined as students' scores on the Mathematics Engagement Scale, while the independent variable was identified as the implementation of cooperative learning–based small-group instruction. Since random assignment was not feasible and the sample was drawn from the classes in which the first author was already teaching.

Sample and Participants

The sample consisted of two intact 5th-grade classes from the same public school, one designated as the experimental group (n=26) and the other as the control group (n=18). Both groups shared similar socio-economic backgrounds, and no additional experimental interventions were conducted in these classes during the study period. To examine group equivalence prior to the intervention, descriptive statistics for pre-test and post-test scores were computed (see Table 1). The pre-test means indicated that the experimental group (M= 124.08, SD = 14.79) and the control group (M= 133.67, SD= 16.43) were broadly comparable at baseline, thereby supporting the internal validity of subsequent analyses. This initial comparability was further reinforced by conducting ANCOVA with pre-test scores entered as covariates, which confirmed that the observed post-test differences could be attributed to the intervention rather than to pre-existing group disparities.

The participating school is located in a district where the local economy is primarily based on farming and animal husbandry, although some parents are employed in the local factory. The families' socioeconomic status can be broadly described as middle-class. Most parents hold a middle school or high school diploma, while those with higher education are in the minority. Family size typically ranges between four and five members.

Table 1

Descriptive statistics for groups and subgroups

Data Set	N	Pre-Test $\bar{X}$	Post-Test $\bar{X}$	Pre-Test SD	Post-Test SD
Experimental group	26	124,08	131,04	14,79	13,91
Control group	18	133,67	129,11	16,43	19,51
Subgroups					

Experimental–Low engagement	8	107,88	119,50	4,82	10,18
Experimental – Moderate/High	18	131,28	136,17	11,56	12,31
Control – Low engagement	6	115,67	112,83	8,31	13,41
Control – Moderate/High	12	142,67	137,25	10,99	17,02

Experimental Process

At the beginning of the study, the Mathematics Lesson Engagement Scale was administered as a pre-test to both groups. Based on the obtained scores, students in each class were categorized into two groups: low engagement (bottom 30%) and moderate/high engagement (top 70%). This classification allowed for a more detailed analysis and resulted in four subgroups: experimental-low, experimental-moderate/high, control-low, and control-moderate/high.

Table 2
Research design

Group	Pre-Test	Intervention	Post-Test
Experimental	Mathematics Engagement Scale	Cooperative learning–based small-group instruction	Mathematics Engagement Scale
Control	Mathematics Engagement Scale	(teacher-centered instruction)	Mathematics Engagement Scale

In the experimental group, mathematics instruction on the unit Categorical Data Distributions was conducted over a five-week period in the 2024–2025 spring term (March 24 – May 2, 2025). Each week, activities were explicitly aligned with national curriculum outcomes MAT.5.5.1 (working with categorical data, making data-based decisions) and MAT.5.5.2 (interpreting and discussing statistical results produced by others). This ensured that cooperative tasks targeted both conceptual understanding and critical interpretation. 26 students were divided into six self-chosen groups, with at least one low-engagement student intentionally placed in each group to ensure balanced participation and peer mentoring. This grouping strategy was not only a logistical choice but also a pedagogical one, designed to foster inclusivity, build confidence among less engaged learners, and cultivate a sense of shared responsibility. In this way, social support and academic growth were intertwined, with students learning with and from one another.

The overall organization of the process was structured according to the Student Teams–Achievement Divisions (STAD) technique (See Table 3). Following the principles of STAD, group work was designed to blend individual accountability with collective achievement. Each week, groups were assigned a thematic task requiring them to prepare and deliver a presentation on the target content. Students rotated through distinct roles such as:

- Presenter: explaining the concept in their own words,
- Media designer: creating or selecting relevant visuals, videos, or digital resources,
- Problem solver: preparing and solving sample questions,
- Coordinator: organizing workflow and ensuring equitable participation.

This structured role rotation not only enhanced accountability but also created opportunities for students to strengthen transversal skills such as communication, creativity, and leadership. In line with STAD's emphasis on both academic and social growth, students were encouraged to integrate real-world data sources (e.g., online media, videos, digital platforms), thereby promoting digital literacy, critical thinking, and the authentic application of mathematics. The teacher's role was intentionally minimized to that of a guide who distributed content themes and provided general direction. Organization of tasks, preparation of materials, and coordination of presentations were left to the students, enabling them to develop self-management, time planning, and metacognitive awareness. In this sense, the classroom became a community of inquiry where responsibility for learning was shared collectively.

Weekly presentations extended the learning process beyond group discussions by incorporating public speaking, peer feedback, and collective evaluation, thereby reinforcing both academic and social-emotional growth. Consistent with the recognition phase of the STAD model, the most effective group was identified each week and rewarded with additional participation points. Importantly, assessment was not limited to grades alone: peer discussions, group self-assessments, and reflective dialogue also contributed to how students monitored their own progress. Throughout the process, the learning outcomes of the Categorical Data Distributions topic—such as working with categorical data, making data-based decisions, and discussing statistical conclusions or interpretations generated by others—were actively emphasized in group work and presentations. Students were thus encouraged not only to share information but also to demonstrate higher-order thinking skills, including data interpretation, evaluation, and decision-making.

By contrast, the control group pursued the same objectives through a teacher-centered, lecture-based approach. Here, students primarily listened to teacher explanations, completed textbook exercises individually, and had limited opportunities for collaboration, feedback, or self-directed learning.

At the end of the five-week implementation, the Mathematics Lesson Engagement Scale was administered as a post-test to both the experimental and control groups. Students' pre- and post-test scores were compared through statistical analyses to determine the effect of cooperative learning–based small-group instruction on mathematics engagement.

Table 3
STAD phases of the current study

STAD phase	Application in this study
Teach	The teacher introduced the thematic content weekly and assigned group presentation tasks.
Team Study	Groups collaboratively prepared presentations, rotating roles (presenter, media designer, problem solver, coordinator) to ensure equitable participation.
Test (Individual Accountability)	Students were individually responsible for understanding the content, as assessed through peer feedback, self-assessments, and reflective discussions following group presentations.
Recognition (Group Rewards)	The most effective group was recognized weekly, with members receiving additional participation points. Group recognition fostered motivation and strengthened teamwork.

Data Collection Instrument

The data collection tool that we used was the Math and Science Engagement Scales. The first version was created by Wang et al. (2016) and was adapted into Turkish by Turan Gürbüz et al. (2020). The scale is a Likert-type measurement tool designed to assess student engagement in math and science lessons. We used the math version. Engagement encompasses relevant behavioral and cognitive dimensions such as participating in discussions, being active in class, group participation, and sustained attention. Turan et al. (2020) reported that three experts translated the scale into Turkish using a language equivalence framework and subjected it to confirmatory factor analysis with a sample of 519 secondary school students. The study confirmed that the scale's four-factor structure was valid ($\chi^2/df = 1.76$, RMSEA = .038, RMR = .010, SRMR = .049, NFI = .99, RFI = .97, CFI = .99, GFI = .99, AGFI = .97). The Turkish version was found to be highly reliable, with Cronbach's alpha equaling .90 and Guttman's half-coefficient equaling .81. This study's findings show the adapted 33-item, 4-dimensional Turkish form is valid and reliable for measuring student participation in math classes (Turan Gürbüz et al., 2020). The scale was used as a pre-test and post-test in a study of cooperative learning-based small-group instruction and student engagement in mathematics.

Data Analysis

This research focused on the impact of cooperative learning within small groups on fifth graders' engagement in mathematics while analyzing the engagement stratification impact. To meet these objectives, a one-way analysis of covariance (ANCOVA) was conducted. ANCOVA is a suitable method in this context because it compares the post-test results of different groups while considering their pre-test results, achieving a more accurate evaluation of the impact of the intervention (Field, 2024).

Two main sets of comparisons were performed: (1) comparison of the experimental group (n = 26) and control group (n = 18), and (2) comparison of the four subgroups categorized based on their engagement levels: control-low (n = 6), control-moderate (n = 12), experimental-low (n = 8), and experimental-moderate/high (n = 18). Pre-test scores were used to adjust for differences and covariates among the groups to better isolate the treatment's impact.

Before applying ANCOVA, its primary assumptions were checked to ensure its validity for the analysis. The dependent variable's normality (post-test scores) was assessed using the Shapiro–Wilk test, and the homogeneity of variances was tested using Levene's test. We evaluated linearity between the covariate (pre-test scores) and the dependent variable through regression analyses, and we checked the assumption of homogeneous regression slopes to confirm that the relationship between the covariate and the dependent variable was consistent across groups. As shown in Table 4, the results of these preliminary analyses revealed that for all groups and subgroups, the p-values of the Shapiro–Wilk and Levene tests were greater than .05. This indicated that the post-test scores were normally distributed and that the group variances were homogeneous, thereby supporting the suitability of ANCOVA for further analyses (Field, 2024). SPSS 27.0 was used to carry out all of the statistical analyses, with the significance level set at $p < .05$.

Table 4

Tests of Normality and Homogeneity of Variance for Post-Test Scores

Dataset	N	Shapiro-Wilk p	Levene p
Experimental group	26	.349	-
Control group	18	.463	-
Experimental vs. Control	-	-	.069
Subgroups			
Experimental–Low engagement	8	.361	-

Experimental – Moderate/High	18	.331	-
Control – Low engagement	6	.202	-
Control – Moderate/High	12	.331	-
Four subgroups	-	-	.512

FINDINGS

Findings for the First Research Question

The first research question examined whether cooperative learnin5th-grademall-group instruction significantly influenced 5th grade students' mathematics engagement compared to traditional instruction. To address this, an ANCOVA was conducted with pre-test scores as the covariate. Prior to the main analysis, the assumption of homogeneity of regression slopes was tested.

As shown in Table 5, the interaction between pre-test scores and group was not significant, $F(1,40) = 0.97$, $p = .33$, indicating that the assumption of homogeneity of regression slopes was met.

Table 5

Test of Homogeneity of Regression Slopes for Post-test Scores by Groups (with Pre-test as Covariate)

Source of Variance	SS	df	MS	F	p
Pre-test	8164,45	1	8164,45	103,82	0,001
Group * Pre-test	76,47	1	76,47	0,97	0,33
Error	3145,58	40	78,64		
Corrected Total	11350,25	43			

Subsequently, ANCOVA was performed with pre-test scores as a covariate (See Table 6). The results indicated a significant difference in post-test engagement scores between the experimental and control groups ($F(1, 41) = 13.67$, $p < .05$, $\eta^2 = .250$). This difference favored the experimental group, whose students demonstrated substantially higher engagement levels in mathematics after the intervention. The effect size ($\eta^2 = .250$) suggested a moderately strong impact, highlighting the practical significance of the cooperative learning–based approach.

Table 6

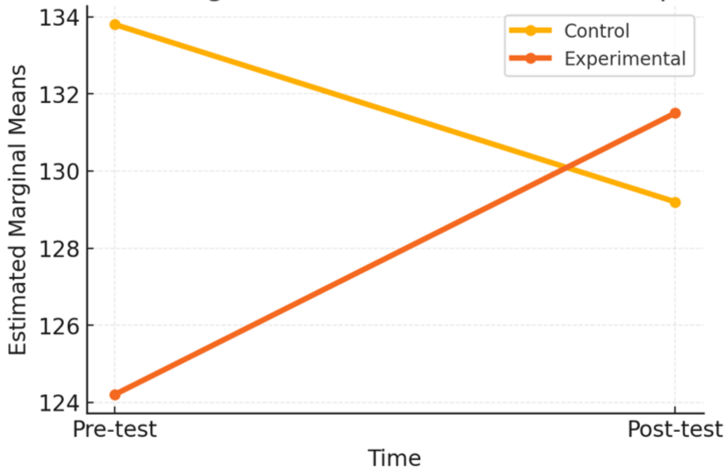
ANCOVA Results for Adjusted Post-test Scores by Groups

Source of Variance	SS	df	MS	F	p	η^2	Significant Difference
Pre-test	8088,70	1	8088,70	102,93	0,001	0,715	Experimental > Control
Group	1074,12	1	1074,12	13,67	0,001	0,250	
Error	3222,04	41	78,586				
Corrected Total	11350,25	43					

To further illustrate these findings, the Estimated Marginal Means (EMM) graph is presented in Figure 1. The graphical representation shows that, while the control group's engagement scores slightly declined from pre-test to post-test, the experimental group displayed a marked increase. This visual pattern is consistent with the ANCOVA results, reinforcing the conclusion that cooperative learning–based instruction enhanced students' participation in mathematics lessons.

Figure 1

Estimated Marginal Means of Engagement Scores for Experimental and Control Groups at Pre-test and



Post-test

Findings for the Second Research Question

The second research question examined whether the effect of cooperative learning–based small-group instruction (CL-SGI) on mathematics engagement differed between fifth-grade students with low engagement levels and those with medium/high engagement levels. To address this, an ANCOVA was conducted using pre-test scores as the covariate. Prior to the analysis, the assumption of homogeneity of regression slopes was tested to ensure the validity of the model (See Table 7).

Table 7

Test of Homogeneity of Regression Slopes for Post-test Scores by Engagement Levels

Source	SS	df	MS	F	p
Pre-test	1490,94	1	1490,94	17,94	0,001
Engagement × Pre-test	5,81	3	18,60	0,22	0,879
Error	2992,50	36	83,125		
Corrected Total	11350,25	43			

The interaction between pre-test scores and engagement groups was not significant, F(3,36) = 0.22, p = .879, indicating that the assumption of homogeneity of regression slopes was met.

Table 8

ANCOVA Results for Adjusted Post-test Scores by Engagement Levels

Source	SS	df	MS	F	p	η²	Significant Difference
Pre-test	4339,28	1	4339,28	55,52	0,001	0,587	Exp. Low > Ctrl. Low
Engagement	1247,86	3	415,95	5,32	0,004	0,290	Exp. Low > Ctrl. Med/High
Error	3048,31	39	78,162				
Corrected Total	11350,25	43					Exp. Med/High > Ctrl.

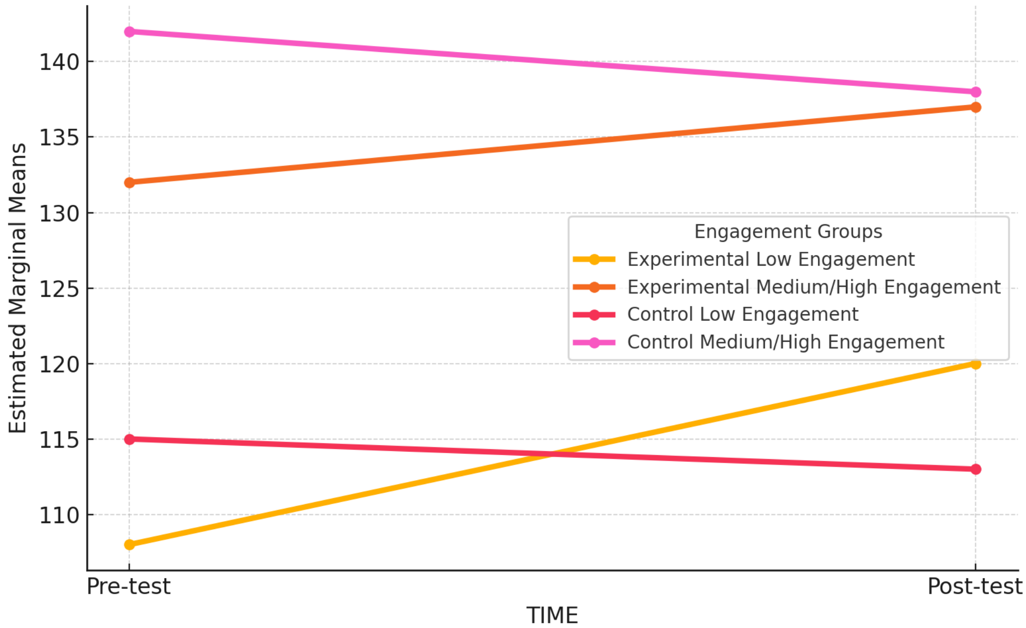
	Med/High

In Table 8, the ANCOVA revealed a significant effect of engagement level on post-test scores after controlling for pre-test, $F(3,39) = 5.32$, $p = .004$, $\eta^2 = .29$. This indicates a medium-to-large effect size. Pairwise comparisons showed that:

- Experimental low-engagement students scored significantly higher than control low-engagement students.
- Experimental low-engagement students also outperformed control medium/high-engagement students.
- Experimental medium/high-engagement students scored significantly higher than their control counterparts.

Figure 1

Estimated Marginal Means of Engagement Scores by Group and Engagement Level (Pre-test, Post-test)



To provide a visual support for these findings, the Estimated Marginal Means graph is presented in Figure 2. This graph illustrates the changes in the estimated mean engagement scores of students in the experimental and control groups over time, categorized by their engagement levels (low and medium/high). Notably, students in the experimental group with low engagement demonstrated a significant increase in their post-test scores. In contrast, students with low engagement in the control group did not show a marked improvement. Furthermore, experimental group students with medium/high engagement also exhibited greater progress compared to their counterparts in the control group.

DISCUSSION

The aim of this study was to assess whether collaborative small-group instruction significantly enhances the engagement of 5th-grade students in mathematics classes. Consistent with expectations, students in the experimental group reported significantly higher engagement scores than those in the control group. Particularly noteworthy is that students with low participation levels benefited most from cooperative methods. Previous research similarly suggests that cooperative learning is particularly effective in fostering active participation and inclusivity among students (Arısoy & Tarım, 2013; Gelici & Bilgin, 2016; Göktaş, 2017; Ünlü & Aydıntan, 2011). Cooperative learning has long been recognised as an approach that promotes engagement across behavioural, emotional, and cognitive domains (Arısoy, 2011). Group work can stimulate excitement, enthusiasm, and a sense of belonging, which in turn enhances motivation and strengthens students' commitment to learning tasks. Peer support, a fundamental element of collaborative learning, fosters both social and cognitive engagement by encouraging students to exchange ideas, explain concepts, and assist each other in problem-solving (Zepke, 2018). These processes deepen cognitive involvement, promote persistence, and enhance behavioural engagement through accountability and active participation—reflecting a constructivist, learner-centred philosophy aligned with the principles of the Türkiye Education Model (MEB, 2024).

The findings also align with those of Suryadi et al. (2024), whose meta-analysis of physical education studies conducted between 2019 and 2024 demonstrated that cooperative learning increases student motivation, social skills, and learning outcomes, while also strengthening classroom engagement. This parallel suggests that when adapted appropriately to student needs, cooperation in game-based learning has a universally positive effect on participation across subjects and contexts.

Our findings also resonate with Demireloğlu Yıldız (2025), who investigated the impact of cooperative learning on 6th-grade students' self-efficacy perceptions and achievement in geometry through a mixed-methods design. While the quantitative data showed significant improvements in self-efficacy but not in achievement, the qualitative findings highlighted students' perceptions of cooperative learning as beneficial for both academic outcomes and social skills. This provides further evidence of the multifaceted benefits of cooperative learning in fostering student engagement. Likewise, Parsons and Taylor (2011) emphasise collaboration as a central means of increasing student engagement, highlighting the role of interaction, reciprocal relationships, and embedded collaboration, which directly align with the principles observed in the present study.

Moreover, subgroup analyses indicated that low-engagement students in the experimental group outperformed not only their low-engagement peers but also medium/high-engagement students in the control group. Medium/high-engagement students in the experimental group likewise demonstrated stronger performance compared to their counterparts in the control condition. This finding is consistent with earlier studies reporting that cooperative learning enhances both academic performance and participation across diverse student groups (Williams, 2005; Sarıkaya, 2022).

Taken together, these results underscore that cooperative learning constitutes a powerful pedagogical strategy for improving engagement in mathematics. Beyond academic performance, it creates an inclusive and supportive learning environment that addresses students' social, emotional, and intellectual needs, thereby sustaining higher levels of motivation and participation.

CONCLUSION and SUGGESTIONS

This study demonstrated that the cooperative learning (CL) method significantly enhanced the participation of fifth-grade students in mathematics lessons. Importantly, students with initially low levels of participation benefited the most, underlining CL's potential to create inclusive and supportive learning environments. The consistent improvement observed across all participation levels in the experimental group further confirms the broad impact of the intervention (Damayanti et al., 2023). By contrast, the limited effectiveness of traditional teacher-centered methods, particularly for low-engagement students, highlights the need for more collaborative and student-centered approaches.

These findings also resonate with the newly introduced Türkiye Education Model (Karabey &

Erdoğan, 2023), which emphasizes not only academic achievement but also the holistic development of students' social, emotional, and ethical capacities. Within this framework, learners are positioned as active participants who take responsibility for their learning and collaborate in decision-making processes (Akpınar et al., 2024). From a classroom practice perspective, this alignment suggests that CL activities in mathematics are not merely tools to increase participation but essential strategies for realizing the learner-centered vision of the Türkiye Education Model. Structured group tasks, in particular, help students develop responsibility, communication, and self-regulation skills while simultaneously deepening their engagement with academic content. The benefits of CL therefore, extend beyond mathematics participation, providing schools with a concrete pathway to embed the broader aims of the Türkiye Education Model in daily classroom practice.

Based on the research findings, several recommendations can be made for both practice and future research. For teachers, it is crucial to identify students with low participation at an early stage and provide targeted support through structured group work. Lesson content should be designed around cooperative learning strategies, and these strategies should be used more systematically to promote engagement and inclusivity. For researchers, future studies should focus on the long-term effects of CL through extended interventions, examine its effectiveness across different grade levels, and investigate the cognitive, behavioral, social, and emotional subdimensions of engagement to generate more nuanced evidence.

Ethical Statement

Ethical approval for the research was taken from the Social and Human Sciences Research Ethics Committee of Osmangazi University with the decision number E-64075176-050.04-250142093. All participants were informed about the purpose of the study, and their voluntary participation and confidentiality of data were ensured.

Author Contributions

Research Design (CRediT 1) Author 1 (%50) – Author 2 (%50)

Data Collection (CRediT 2) Author 1 (%80) – Author 2 (%20)

Data analysis - Validation (CRediT 3-4-6-11) Author 1 (%80) – Author 2 (%20)

Writing the Article (CRediT 12-13) Author 1 (%30) – Author 2 (%70)

Revision and Improvement of the Text (CRediT 14) Author 1 (%30) – Author 2 (%70)

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. One of the authors, Melek Alemdar, is a member of the editorial board of this journal. To safeguard the integrity of the review process, editorial handling and the final decision were conducted independently by another editor, without any involvement from the author.

Sustainable Development Goals (SDG)

This study supports **SDG 4** (Quality Education) by demonstrating that cooperative learning-based small-group instruction fosters higher engagement in mathematics compared to traditional methods, promoting active learning, critical thinking, and social-emotional skills in line with 21st-century competencies. Furthermore, the findings contribute to **SDG 10** (Reduced Inequalities), as the instructional approach particularly benefited initially low-engagement students, highlighting the inclusive potential of cooperative learning to reduce disparities in educational participation and achievement.

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