The Enhancing Classroom Participation and Mathematics Achievement Through Cooperative Learning for Grade 3 Students.

การส่งเสริมการมีส่วนร่วมในชั้นเรียนและผลสัมฤทธิ์ทางคณิตศาสตร์ ผ่านการเรียนรู้แบบร่วมมือของนักเรียนชั้นประถมศึกษาปีที่ 3

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Abstract

The research objectives are to: 1) examine the participation in mathematics classes among third-grade students following the implementation of cooperative learning, 2) compare the mathematics achievement following participation in cooperative learning with the 80% criteria, and 3) investigate students' satisfaction with the cooperative learning approach. The sample consisted of 90 third-grade students from Hangzhou Qiushi Primary School in China, selected through simple random sampling. The research tools included a set of instructional activity plans, an achievement test featuring consisting of examination fill-in-blank, multiple-choice items, subjective, and a student satisfaction survey focused on cooperative learning. Data were analyzed using mean (), standard deviation (SD), and hypothesis testing with a one-sample t-test.

The study revealed the following results: 1) Students' participation in mathematics classes following the implementation of cooperative learning was overall at a high level ($\bar{x}$ = 3.72, S.D.= 0.70). Among the dimensions, emotional participation obtained the highest mean score ($\bar{x}$ =4.15, S.D.= 0.68), followed by behavioral participation ($\bar{x}$ =4.04, S.D.=0.77). Regarding cognitive participation, students consistently applied higher-order thinking strategies. Nevertheless, some students with lower levels of participation experienced difficulties in expressing their opinions and felt excluded from group activities. 2) Students' mathematics achievement after engaging in cooperative learning reached an average of 85.60% (t=8.94, p<0.05), which was significantly higher than the expected benchmark. 3) Students expressed a high level of satisfaction with cooperative learning, with a mean score of ($\bar{x}$ =4.42, S.D.=0.53).

Keywords: Cooperative Learning, Mathematics Achievement, Participation, Learning Outcomes

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อ 1) ศึกษาการมีส่วนร่วมในการเรียนคณิตศาสตร์ของนักเรียนชั้นประถมศึกษาปีที่ 3 ภายหลังการจัดการเรียนรู้แบบร่วมมือ 2) เปรียบเทียบผลสัมฤทธิ์ทางการเรียนคณิตศาสตร์ภายหลังการเรียนรู้แบบร่วมมือกับเกณฑ์ร้อยละ 80 และ 3) ศึกษาความพึงพอใจของนักเรียนที่มีต่อการจัดการเรียนรู้แบบร่วมมือ กลุ่มตัวอย่างเป็นนักเรียนชั้นประถมศึกษาปีที่ 3 จำนวน 90 คน โรงเรียนประถมศึกษา ฉือซือ สาธารณรัฐประชาชนจีน โดยเลือกด้วยวิธีการสุ่มอย่างง่าย เครื่องมือวิจัยประกอบด้วย แผนการจัดกิจกรรมการเรียนรู้ แบบทดสอบผลสัมฤทธิ์ทางการเรียนซึ่งมีทั้งรูปแบบปรนัยและอัตนัย และแบบสอบถามความพึงพอใจต่อการเรียนรู้แบบร่วมมือ วิเคราะห์ข้อมูลโดยหาค่าเฉลี่ย () ส่วนเบี่ยงเบนมาตรฐาน (SD) และการทดสอบสมมติฐานด้วยสถิติ t แบบกลุ่มตัวอย่างเดียว

ผลการวิจัยพบว่า 1) การมีส่วนร่วมของนักเรียนในการเรียนวิชาคณิตศาสตร์ ภายหลังการจัดการเรียนรู้แบบร่วมมืออยู่โดยรวมอยู่ในระดับสูง ($\bar{x}$ =3.72, S.D.=0.70) ประกอบด้วย การมีส่วนร่วมด้านอารมณ์มีค่าเฉลี่ยสูงที่สุด ($\bar{x}$ =4.15, S.D.=0.68) รองลงมาคือการมีส่วนร่วมด้านพฤติกรรม ($\bar{x}$ =4.04, S.D.=0.77) สำหรับการมีส่วนร่วมด้านการรับรู้ นักเรียนสามารถประยุกต์ใช้กลยุทธ์การคิดขั้นสูงได้อย่างต่อเนื่อง นักเรียนบางส่วนที่มีระดับการมีส่วนร่วมต่ำ พบความยากลำบากในการแสดงความคิดเห็นและรู้สึกถูกกีดกันจากกิจกรรมกลุ่ม 2) ผลสัมฤทธิ์ทางการเรียนคณิตศาสตร์ของนักเรียนภายหลังการเรียนรู้แบบร่วมมือมีค่าเฉลี่ยที่ร้อยละ 85.60 ($t = 8.94$, $p < 0.05$) ซึ่งสูงกว่าเกณฑ์ที่คาดหมายอย่างมีนัยสำคัญ 3) นักเรียนมีความพึงพอใจต่อการเรียนรู้แบบร่วมมือในระดับสูง ($\bar{x}$ =4.42, S.D.=0.53)

คำสำคัญ: การเรียนรู้แบบร่วมมือ, ผลสัมฤทธิ์ทางการเรียนคณิตศาสตร์, การมีส่วนร่วม, ผลการเรียนรู้

Introduction

Globally, educational reforms prioritize active student participation to enhance learning outcomes. China's 2001 Basic Education Curriculum Reform Outline mandated a shift from passive, rote learning to student-centered approaches emphasizing exploration, questioning, and collaboration (Ministry of Education of China, 2001). This aimed to holistically develop students' cognitive, emotional, and social skills. These reforms highlight the growing global emphasis on active student engagement as a key driver for effective learning.

The 2021 "Double Reduction" policy further stressed improving classroom quality to reduce burdens from excessive homework and tutoring, making student engagement strategically critical (Ministry of Education of China, 2021). A 2024 study by Engageli (2024) demonstrated 54% higher test scores in active learning sessions compared to traditional lectures. Moreover, active participation is linked to improved metacognitive skills and self-regulated learning (Zimmerman, 2002; Vygotsky, 1978).

Despite these efforts, low engagement persists, especially in elementary classrooms. Observational studies show many students remain passive and unmotivated, particularly in mathematics where complexity and abstract reasoning challenge younger learners (Zhang, 2018). Third grade is a foundational period; disengagement here can negatively impact long-term math attitudes and problem-solving abilities.

Cooperative learning, where students work interdependently towards shared goals (Johnson & Johnson, 1999), is advocated to address this. It fosters academic achievement, collaborative skills, motivation, and satisfaction (Slavin, 1986). However, research on its application in primary mathematics, especially grade three, is limited.

The effectiveness of cooperative learning is underpinned by several key elements, including positive interdependence, individual accountability, promotive interaction, social skills, and group processing (Johnson & Johnson, 2009). These structural components are designed not only to elevate academic performance through peer explanation and cognitive restructuring but also to enhance non-cognitive outcomes such as motivation, interpersonal relations, and attitudes toward learning. Academic achievement within cooperative settings is frequently measured via standardized test scores and task-based assessments, which reflect deepened conceptual understanding and problem-solving proficiency. Concurrently, variables such as satisfaction often operationalized as students' perceived enjoyment, value, and sense of belonging in the classroom are critically tied to continued engagement and intrinsic motivation (Gillies, 2016). These variables are particularly salient in the context of the present study, as engagement is multifaceted, encompassing behavioral, cognitive, and affective dimensions. The interrelated nature of achievement, satisfaction, and engagement suggests that improvements in cooperative learning environments may form a virtuous cycle: increased achievement fosters confidence and satisfaction, which in turn promotes deeper and more sustained cognitive and behavioral engagement. Therefore, examining both academic and affective outcomes offers a holistic understanding of how structured cooperative learning shapes student experiences in primary mathematics.

At Hangzhou Qiushi Primary School, third-grade math classes show limited engagement and participation, often dominated by a few students. Unstructured group work can lead to unequal participation and reduced effectiveness (Zhang et al., 2024). Structured role allocation and rotation may promote equity. Implementing structured cooperative learning with defined roles and systematic rotation has been shown to enhance equitable participation and maximize group effectiveness (Johnson & Johnson, 2009).

Therefore, this study adopts a structured pedagogical model grounded in Slavin's five-step cooperative learning framework. This framework is distinct from general cooperative learning management approaches, as it emphasizes a structured sequence of implementation to ensure positive interdependence and individual accountability. Specifically, the following steps were operationalized in the third-grade mathematics classrooms:

1. Forming groups: The teacher organizes students into groups of 4-5 members to facilitate effective communication and collaboration.

2. Setting goals: clear and achievable learning goals are established for each group to motivate cooperative effort.

3. Assigning tasks: each group member receives a specific role and responsibility to ensure active participation.

4. Monitoring progress: the teacher supervises group activities, offering guidance and support as needed to maintain focus.

5. Evaluating outcomes: achievement are assessed and feedback is provided to encourage continuous group engagement.

In summary, this study investigates the impact of structured cooperative learning on third-grade students' participation, academic achievement, and learning satisfaction in mathematics. It aims to provide evidence to improve instructional quality and foster confident, competent, lifelong learners.

Research Objective

1. To examine the participation in mathematics classes among third-grade students following the implementation of cooperative learning.

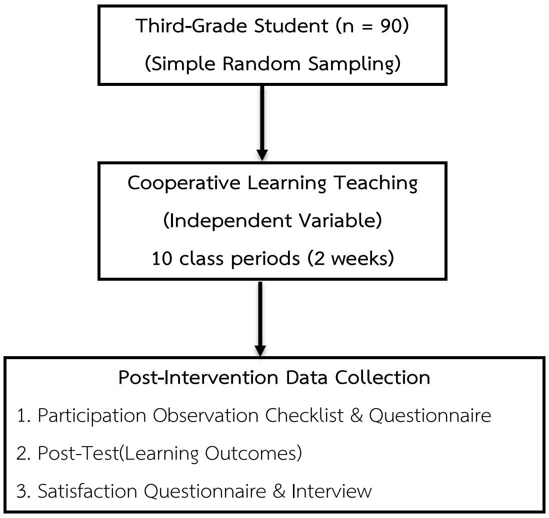
2. To compare the mathematics achievement following participation in cooperative learning with the 80% criteria.

3. To explore students' satisfaction with the cooperative learning approach.

Methodology

1. Research Design

This study employed a quasi-experimental one-group posttest-only design to assess the impact of cooperative learning. A cooperative learning intervention was implemented over a two-week period, consisting of 10 sessions. Participation, academic achievement, and satisfaction were measured after the intervention using post-intervention assessments. No control group was used; instead, results were compared against pre-established curriculum standards.



Picture 1 Research Design Flowchart – One-Group Posttest-Only Design

2. Population and Sample

The population of this study comprises all third-grade students (approximately 360 students across 8 classes) enrolled at Hangzhou Qiu Shi Primary School during the academic year 2024–2025.The sample consists of 90 third-grade students drawn from this population. To ensure representativeness, a simple random sampling method was employed at the classroom level. Given that the eight third-grade classes were homogeneously grouped (i.e., students were evenly distributed across classes based on academic ability and other relevant factors at the start of the grade), two classrooms were randomly selected. All students within these two selected classrooms participated in the study. This resulted in a sample size of 90 students (45 students per class). All sampled students participated in the cooperative learning intervention integrated into their regular mathematics instruction over a two-week period.

3. Research Variables

Table 1 Research Variables

Variable Type	Components
Independent	Cooperative learning based on Slavin's 5-step model: 1. Forming groups: The teacher organizes students into groups of 4-5 members to facilitate effective communication and collaboration. 2. Setting goals: clear and achievable learning goals are established for each group to motivate cooperative effort. 3. Assigning tasks: each group member receives a specific role and responsibility to ensure active participation. 4. Monitoring progress: the teacher supervises group activities, offering guidance and support as needed to maintain focus. 5. Evaluating outcomes: achievement are assessed and feedback is provided to encourage continuous group engagement.

Variable Type	Components
Dependent	1. Participation: behavioral, cognitive, and emotional dimensions. 2. Learning outcomes: post-test scores on division concepts. 3. Satisfaction: learning experience enjoyment, group effectiveness, and teaching activity support.
Controlled	Instructional content (Unit 2: Division), instructional time (8 hours), teacher, and classroom environment.

4. Research Instruments

Table 2 Research Instruments

Instrument	Purpose	Key Features	Validity/Reliability
Cooperative Learning Plan	To implement the intervention	Structured based on Slavin's 5-step cooperative learning model; aligned with division curriculum content.	Content validity confirmed by experts (IOC=1.00)
Observation Checklist	To measure participation	15 items covering behavioral, cognitive, and emotional dimensions; rated on a 5-point Likert scale.	Content validity (IOC = 1.00)
Participation Questionnaire	To gather self-reported participation data	15 items across three participation dimensions; 5-point Likert scale.	Internal consistency reliability (Cronbach's α = 0.82)
Post-Test	To assess academic learning outcome	13 items including objective (fill-in-the-blank 6 items, multiple-choice 4 items) and subjective questions 3 items; 30-minute test duration.	Difficulty Index (0.29-0.81); Discrimination Index (0.32-0.94). Reliability (Cronbach's α = 0.74).
Satisfaction Questionnaire	To measure students' satisfaction with the learning approach	12 items on enjoyment, group efficacy, and teaching design; 5-point Likert scale.	Internal consistency reliability (Cronbach's α = 0.83)
Semi-Structured Interviews	To collect qualitative insights on student experiences	Conducted with 10 students stratified by participation level; analyzed using thematic analysis.	Content validity confirmed by experts (IOC = 1.00)

5. Data Collection Procedure

5.1 Preparation

5.1.1 Obtained formal approval and consent from the school administration and parents of participating students.

5.1.2 Trained research assistants and observers on the consistent use of observation checklists to ensure inter-rater reliability.

5.2 Intervention Implementation

5.2.1 Conducted 10 cooperative learning sessions, each lasting approximately 45–50 minutes, integrated into regular mathematics instruction over two weeks.

5.2.2 Organized students into groups of 4–5 members with systematically rotated roles (e.g., leader, recorder, presenter) to promote equitable participation.

5.3 Post-Intervention Data Collection

5.3.1 Measured participation through both observer-rated checklists and student self-report questionnaires.

5.3.2 Assessed academic achievement using a standardized post-test aligned with curriculum objectives.

5.3.3 Evaluated student satisfaction via questionnaires and semi-structured interviews with a stratified sample of 10 students representing various participation levels.

5.4 Data Verification and Management

5.4.1 Quantitative data were entered and analyzed using Microsoft Excel for descriptive statistics and inferential tests.

5.4.2 Qualitative interview data were audio-recorded, transcribed verbatim, and analyzed thematically to identify recurring patterns and insights.

6. Data Analysis

6.1 Participation

6.1.1. Calculated means and standard deviations for behavioral, cognitive, and emotional participation dimensions.

6.1.2 Classified participation levels based on the following Likert (1932) scale:

4.21–5.00: Very High

3.41–4.20: High

2.61–3.40: Moderate

1.81–2.60: Low

1.00–1.80: Very Low

6.2 Academic Achievement

6.2.1 Employed a one-sample t-test to compare students' post-test scores against the established benchmark of 80%.

6.2.2 Conducted descriptive statistical analyses to examine performance differences across question types (objective vs. subjective).

6.3 Student Satisfaction

6.3.1 Computed mean scores and standard deviations for satisfaction domains, including learning enjoyment, group efficacy, and teaching design.

6.3.2 Applied thematic analysis to interview transcripts, systematically coding data to extract themes related to students' learning experiences and perceptions.

Research Results

1. Study results on classroom participation

To assess the classroom participation following the cooperative learning intervention, data were collected through both instructor observations and student self-assessments. Participation was evaluated across three dimensions: behavioral, cognitive, and emotional participation. The following Table 3 presents the summarized results from the classroom participation observation checklist, highlighting students' engagement patterns during mathematics lessons.

Table 3 The results of the data collection by using the participation observation form

Dimension		Observation Item	Mean	S.D.	Level of Participation
Behavioral Participation		1. Focused listening	4.32	0.58	very high
		2. Task persistence	4.18	0.67	high
		3. Active response	3.87	0.82	high
		4. Contribution to group work	4.25	0.71	very high
		5. Inquiry persistence	3.95	0.79	high
		Overall	**4.11**	**0.71**	**high**
Cognitive Participation	**Higher-order strategy**	7. Deep strategy (conceptual connections)	4.28	0.63	very high
		9. Question quality	3.82	0.75	high
		10. Strategy adjustment	4.02	0.69	high
		Overall	**4.04**	**0.69**	**high**
	Low order strategy	6. Surface strategy (mechanical application)	2.15	0.91	low
		8. Dependent strategy (seeking help)	3.03	0.87	moderate
		Overall	**2.59**	**0.89**	**low**
Emotional Participation		11. Learning interest	4.41	0.52	very high
		12. Success experience	4.23	0.61	very high
		13. Anxiety **(reverse-scored)**	4.15	0.72	high
		14. Boredom **(reverse-scored)**	4.08	0.78	high
		15. Cooperative attitude	4.20	0.67	high
		Overall	**4.21**	**0.66**	**very high**
		Overview	**3.74**	**0.70**	**high**

From Table 3, the overall level of student participation has reached a high level ($\bar{x}$=3.74, S.D.=0.70). Specifically, in each aspect, the overall behavioral participation is high level, indicating that students generally maintain focused listening, persist in tasks, and actively contribute to group work. Cognitive participation results reveal that students engage more in higher-order thinking strategies, such as conceptual connections and strategic adjustments, rather than surface or dependent strategies. Emotional participation scores suggest students have strong interest, positive feelings, and cooperative attitudes toward learning.

In addition to instructor observations, students' self-assessments were collected to provide a complementary perspective on their own participation during the cooperative learning sessions. Table 4 summarizes the results from the participation assessment questionnaires, illustrating how students perceive their behavioral, cognitive, and emotional participation in the mathematics classroom.

Table 4 The results of the data collection by using participation assessment form

Dimension		Observation Item	Mean	S.D.	Level of Participation
Behavioral Participation		1. Maintaining focus	4.15	0.73	high
		2. Persisting with tasks	4.07	0.77	high
		3. Asking questions actively	3.82	0.85	high
		4. Sharing ideas	4.20	0.71	high
		5. Attempting multiple approaches	3.96	0.80	high
		Overall	**4.04**	**0.77**	**high**
Cognitive Participation	**Higher-order strategy**	7. Connecting prior knowledge	4.23	0.65	very high
		9. Raising analytical questions	3.78	0.76	high
		10. Adjusting strategies based on feedback	4.05	0.70	high
		Overall	**4.02**	**0.70**	**high**
	Low order strategy	6. Repetitive practice	2.18	0.88	low
		8. Relying on teacher guidance	3.12	0.82	moderate
		Overall	**2.65**	**0.85**	**moderate**
Emotional Participation		11. Finding math lessons interesting	4.38	0.57	very high
		12. Feeling proud when solving difficult problems	4.18	0.66	high
		13. Learning anxiety **(reverse-scored)**	4.07	0.75	high
		14. Perceived dullness **(reverse-scored)**	3.95	0.81	high
		15. Actively helping peers	4.28	0.62	very high
		Overall	**4.15**	**0.68**	**high**
		Overview	**3.72**	**0.74**	**high**

The data from the participation self-assessment reveal that the overall level of student participation has reached a high level (= 3.72, SD = 0.74). And students rated their behavioral participation as high, demonstrating active involvement such as sharing ideas and persisting with tasks. Cognitive participation also showed a high level for higher-order strategies like connecting prior knowledge and adjusting strategies based on feedback, while lower-order strategies were rated moderately. Emotional participation was reported as high, indicating students generally found the math lessons interesting and felt proud when solving problems. These findings align with the observational data and suggest positive engagement across multiple dimensions.

2. Study results on achievement

To evaluate the effectiveness of the cooperative learning intervention on students' academic performance, a post-test was administered following the completion of the program. The test scores were compared against a predefined benchmark of 80 percent to determine whether students met or exceeded the expected level of proficiency in mathematics. Table 5 presents the results of the one-sample t-test comparing the mean post-test score to the benchmark.

Table 5 One-Sample t-Test Results for Post-Test Total Score (Benchmark = 80)

n	**Test Value**	Full Score	**Mean Score**	**S.D.**	**t-value**	**df**	**p-value**
90	80	100	85.6	6.8	8.94	89	< 0.001

Statistical significance level: *p< 0.05

As shown in Table 5, the average post-test score of 85.6 was significantly higher than the benchmark score of 80 ($t = 8.94$, $p < 0.05$). This indicates that the cooperative learning approach effectively enhanced students' overall mathematical achievement, demonstrating a meaningful improvement in their understanding and application of division concepts.

To further analyze students' performance, the post-test scores were disaggregated by question type to examine differences in achievement across various cognitive demands. Table 6 details the descriptive statistics for fill-in-the-blank, multiple-choice, and subjective problem-solving items, along with their respective comparisons to the 80% benchmark.

Table 6 Descriptive statistical analysis results of scores in various dimensions

Dimension	Max Score	Mean Score	S.D.	80% Benchmark	Percentage difference
Fill-in-blank (concepts and calculations)	36	31.2	3.1	28.8	**8.33**
Multiple-choice (analysis and judgment)	24	21.2	2.2	19.2	**10.42**
Subjective (problem-solving)	40	33.2	5.1	32.0	**3.75**
Total	**100**	**85.6**	**6.8**	**80.0**	**7.00**

The results in Table 6 reveal that students showed the greatest improvement in multiple-choice questions, with a 10.42% increase over the benchmark, followed by fill-in-the-blank items with an 8.33% gain. Subjective problem-solving questions showed a smaller improvement of 3.75%, reflecting the greater challenge of higher-order thinking skills. Overall, these findings suggest that cooperative learning most effectively supports foundational knowledge acquisition while still contributing to the development of complex problem-solving abilities.

3. The study results on students' satisfaction with cooperative learning

Student satisfaction with the cooperative learning approach was assessed through a structured questionnaire covering three main domains: experience joy, group efficacy, and teaching design. The following table (Table 7) presents the mean scores and quality levels for each item, indicating students' overall perceptions and attitudes toward the learning experience.

Table 7 The results of the data collection by using satisfaction assessment form

Dimension	Item	Mean	S.D.	Level of Satisfaction
Experience Joy	Enjoyed cooperative learning	4.48	0.52	very High
	Group discussions were fun	4.36	0.58	high
	Learning process was enjoyable	4.42	0.54	very High
	Willing to continue cooperation	4.41	0.56	very High
	Overall	**4.42**	**0.55**	**very High**
Group Efficacy	Enhanced math understanding	4.18	0.61	high
	Improved problem-solving	4.21	0.59	high
	Effective peer assistance	4.35	0.55	very High
	Facilitated learning outcomes	4.27	0.57	high
	Overall	**4.25**	**0.58**	**high**
Teaching Design	Well-organized activities	4.63	0.45	very High
	Clear task responsibilities	4.53	0.49	very High
	Overall satisfaction	4.57	0.43	very High
	Beneficial cooperative climate	4.60	0.41	very High
	Overall	**4.58**	**0.45**	**very High**
	Overview	**4.42**	**0.53**	**very High**

The results reveal that the overall satisfaction level of students has reached a very high level ($\bar{x}$=4.42, S.D.=0.53). And showed that high levels of satisfaction across all domains, particularly in aspects related to enjoyment of learning activities and perceived group effectiveness. These findings suggest that the cooperative learning approach not only supported academic and participatory engagement but also fostered a positive emotional and social learning environment for the students.

To gain deeper insight into students' learning experiences, semi-structured interviews were conducted with ten participants selected based on varied levels of observed participation. Thematic analysis was used to interpret students' perspectives on cooperative learning, including perceived benefits, challenges, and suggestions for improvement. The summary of emerging themes and representative quotes is presented in Table 8.

Table 8 The results of the data collection by using semi-structured satisfaction interviews (n=10)

Theme Dimension	High Participation Students (n=3)	Medium Participation Students (n=3)	Low Participation Students (n=4)
Learning experience enjoyment	"Grouping with fruits! We divided strawberries to practice division, and got to eat them afterward – so much fun!" "The teacher let us use LEGO blocks for division. I taught my group as the 'little teacher'!" "I wish the teacher taught this way every day! I even taught my little brother to divide cookies at home."	"Way more interesting than worksheets! When sharing candies, I finally understood that remainders are like extra sweets." "Our group won stickers in the division speed contest!" "Hope we keep learning in groups."	"I used to be scared of division, but now teammates help me split counting rods. They don't laugh when I make mistakes." "Math class doesn't scare me anymore" (murmured while playing with manipulatives) "I didn't want to join discussions because I couldn't express myself."
Group Effectiveness	"When teaching classmate 'containment division,' I said 'it's like packing gift boxes' – she got it instantly!" "Through our strawberry division game, the whole group mastered remainders!"	"A classmate noticed I kept forgetting to write 'remainder.' Now they remind me every time!" "As the materials distributor, I learned 'equal sharing' while handing out tools."	"They guided me to count rods: 12 rods ÷ 3 groups = 4 each. That's how I learned division." "Teammates thought I couldn't do well and wouldn't let me participate."
Teaching Activity Support	"The game was awesome! Our group solved the 'supermarket sorting' division challenge fastest!" "Our teacher said 'daring to make mistakes is bravery,' so our group tried new methods boldly!"	"The balloon-sharing task made sense – much easier than word problems in workbooks!" "I earned the 'Division Whiz' sticker last week for most progress!"	"When solving problems, our leader helps me identify key words in questions." "Hearing teammates say 'try again' calms me down" (fidgeting with divided erasers)

The interview results supported the quantitative findings, providing deeper insights into students' experiences with cooperative learning. Most students expressed that the activities were "fun and exciting" and allowed them to "learn better by helping and talking with friends." Several students appreciated the sense of teamwork, stating that "when we solve problems together, it's easier to understand." While a few participants noted challengessuch as "some friends don't talk much" or "we ran out of time to finish all questions"the overall tone remained positive. These qualitative responses help to contextualize the improved levels of satisfaction and reinforce the value of cooperative structures in engaging young learners.

Discussion of results

This study extends the existing literature on cooperative learning by specifically examining its implementation within the relatively constrained timeframe of 10 class periods, a duration less commonly explored in similar interventions. While many studies report outcomes from longer-term implementations, our findings demonstrate that even short-term, structured cooperative activities can yield significant improvements in behavioral and emotional participation, as well as academic achievement. However, the limited intervention period also brings to light certain constraints, particularly in fostering deep cognitive engagement among all students, especially those initially less participatory. The most salient contribution of this work lies in its emphasis on structured role allocation and scaffolding as critical mechanisms for enhancing equity in participation, a nuance that is often underemphasized in prior studies. Below, we discuss these findings in relation to each research objective, highlighting both strengths and limitations observed during the study.

1. Discussion of Research Results

1.1 Mechanisms of Participation Enhancement

The high levels of behavioral and emotional engagement observed in this study reflect the effective application of Social Interdependence Theory (Deutsch, 1949). Specifically, the design of cooperative learning activities with clearly defined roles such as "group leader" or "materials manager" fostered positive interdependence and accountability. This supports Slavin (1986) argument that "group success precedes individual success," and explains the strong indicators of active participation such as task persistence (M_observed = 4.18) and peer encouragement (M_self-assessed = 4.28). These findings align with the results of Johnson and Johnson (2009), who found that structured roles and interdependence significantly increased student engagement and participation.

The study also revealed evidence of cognitive scaffolding within peer interactions. The use of higher-order strategies such as "adjusting approaches based on group feedback" (M = 4.02) is consistent with Vygotsky's (1978) concept of the Zone of Proximal Development (ZPD), wherein learners extend their cognitive capabilities through guided interaction with more competent peers. This observation is supported by Gillies (2016), who reported that scaffolding in peer-led discussions enhances both individual understanding and group synergy.

However, qualitative data highlighted challenges for some students with lower participation levels. Several interviewees reported feeling "excluded from discussions," revealing that cooperative learning without structured facilitation may lead to imbalanced engagement. This echoes Gillies (2003) warning that, in the absence of clear participation protocols, dominant voices may marginalize quieter students. Additionally, research by Järvelä et al. (2010) confirms that effective teacher monitoring and feedback are essential to maintaining equitable collaboration, especially for low-engagement learners.

Notably, the 10 session intervention proved sufficient to elevate participation in behavioral and emotional domains, but may have been inadequate to fully cultivate cognitive participation particularly higher-order thinking among all learners. This limitation underscores the need for longer and more scaffolded interventions to ensure sustained and inclusive cognitive engagement.

In sum, the cooperative learning model enhanced participation through mechanisms of shared goals, peer scaffolding, and social motivation. Nonetheless, differentiated support strategies such as structured turn-taking and role rotation are essential to ensure inclusivity and equitable engagement for all learners.

1.2 Academic Achievement Drivers

The 7% increase in post-test scores following the intervention supports Johnson and Johnson (1999) assertion that cooperative learning “maximizes individual and collective learning.” The most significant improvement was in multiple-choice items (+10.42%), indicating enhanced conceptual understanding and recall. Peer teaching, elaborative rehearsal, and shared problem-solving may account for this gain, aligning with cognitive learning theories emphasizing knowledge construction through dialogue (Slavin, 1996). Cooperative learning strategies elevated mathematics achievement in Chinese primary students, with meta-analytic evidence showing strong effects (d = +0.67) on performance (Zhang et al., 2018).

Students’ reflections, such as “I explained containment division to my group,” illustrate how cooperative environments promote metacognition and social construction of meaning. These findings are consistent with meta-analyses by Öztürk (2023) and Yaşar et al. (2024), who found strong positive effects of cooperative learning on academic outcomes, particularly in STEM disciplines.

However, the more modest improvement in subjective items (+3.75%) suggests limited impact on higher-order thinking and abstract reasoning. This aligns with Alanazi (2016) argument that “collaboration alone cannot replace deep individual conceptualization.” Open-ended tasks may require more individualized time for processing, internalization, and synthesis components less emphasized in group formats. Similarly, Kyndt et al. (2013) caution that without targeted support, cooperative structures may underperform in fostering higher-order reasoning skills.

These outcomes directly address the second research objective, confirming that cooperative learning can significantly exceed the 80% benchmark in overall achievement. However, the disparity in improvement across question types also highlights a weakness: the approach may be more effective in reinforcing foundational knowledge than in developing complex problem-solving skills. This suggests a need for more intentional scaffolding of higher-order tasks within the cooperative framework.

These findings highlight the dual role of cooperative learning: while it enhances engagement and conceptual understanding, its impact on complex cognitive tasks may be restricted without complementary instructional strategies. A hybrid model that integrates cooperative structures with explicit instruction, guided practice, and individual problem-solving could provide more holistic cognitive development (Bruner, 1966; Huang et al., 2023; Sungur & Tekkaya, 2006).

1.3 Satisfaction and Implementation Challenges

The overall high satisfaction levels reported by students ($M_{design} = 4.58$; $M_{enjoyment} = 4.42$) reflect the benefits of active, constructivist learning. Engaging activities such as the “strawberry division game” offered students a hands-on, socially interactive experience that aligns with Piaget’s (1970) theory of experiential learning and Vygotsky's (1978) sociocultural approach emphasizing interaction and scaffolding. Cooperative learning elevated elementary students' enjoyment, motivation, and confidence in mathematics, with structured peer interaction reducing anxiety and promoting self-efficacy (Kose et al., 2010).

Nonetheless, feedback from low-engagement students underscored structural issues particularly the lack of clear task division and role enforcement leading to feelings of exclusion. Similar concerns are reported in Zhang et al. (2024), who found that without structured role rotation, cooperative learning may fail to ensure balanced participation. These challenges resonate with the findings of Webb (2008), who argued that satisfaction depends heavily on equal participation and clear group expectations.

These satisfaction results align with the third research objective and affirm that well-designed cooperative learning is highly enjoyable and perceived as effective. However, the reported challenges also indicate that satisfaction is closely tied to perceived inclusivity and equity issues that must be proactively addressed through better scaffolding and facilitation.

To address these limitations, the use of rotating roles, explicit task responsibilities, and teacher-led facilitation is recommended. Slavin (1996), Johnson & Johnson (2009), and Gillies (2016) emphasize that well-defined group structures enhance group functioning and satisfaction. Moreover, Belland et al. (2017) and Michaelsen et al. (2008) advocate for inclusive climates and equitable accountability to maximize the effectiveness of group-based learning.

In conclusion, while the cooperative learning model in this study fostered high levels of satisfaction and foundational learning, implementation quality is crucial. Attention to role clarity, group balance, and scaffolding is essential to ensure that cooperative environments are inclusive, cognitively effective, and emotionally supportive for all learners.

Suggestions of Research Results

The following suggestions are formulated based on the empirical findings and practical observations of this study, with particular emphasis on enhancing participatory equity and cognitive depth through scaffolding a dimension that distinguishes this study from prior work.

1. Implementation Suggestions

1.1 Systematize Role Allocation. It is recommended to implement a systematic approach for assigning and rotating specific roles within cooperative groups, such as "strategy coordinator" and "equity monitor." This practice will help ensure that all students actively engage in higher-order cognitive tasks, thereby addressing observed cognitive stratification and promoting equitable participation.

1.2 Enhance Scaffolding in Problem Solving Tasks. To bridge the gap between foundational knowledge and applied problem solving skills, educators should integrate multi-stage, authentic tasks with built-in cognitive scaffolding. For instance, teachers may provide think-aloud protocols, guided questioning frameworks, or visual organizers to support reasoning during group work. Such strategies are essential to elevate cognitive participation and ensure that all students, especially those struggling, can engage in higher-order thinking.

1.3 Standardize Teacher Training. Providing standardized professional development is essential to equip teachers with effective techniques, including conflict-resolution protocols and scaffolding methods grounded in Vygotsky's Zone of Proximal Development (ZPD). These skills are crucial to support students with lower participation levels and to facilitate balanced group dynamics.

1.4 Leverage Mixed Assessment Strategies. Combining group-based rewards with individual accountability measuressuch as reflection journalscan promote positive interdependence while ensuring personal responsibility. This balanced assessment approach supports motivation and self-regulated learning within cooperative frameworks.

2. Future Research Suggestions

2.1 Investigate Long-Term Effects. Future studies should explore the longitudinal impact of cooperative learning on the development of higher-order mathematical reasoning, such as algebraic thinking, by tracking student cohorts through multiple grade levels (e.g., from Grade 3 to Grade 5).

2.2 Examine Scaffolding Mechanisms in Depth. Further research should focus on how different types of scaffolding (e.g., peer, teacher, or digital scaffolding) can be integrated within cooperative learning structures to foster deeper and more equitable cognitive participation. Comparative studies may identify optimal scaffolding strategies that support sustained engagement across diverse learner profiles.

2.3 Explore Technology Integration. Research into the application of technology, such as AI-assisted role assignment tools, could address participation inequities revealed in qualitative findings. Such innovations may facilitate dynamic and equitable group formations, thereby enhancing engagement for all learners.

2.4 Expand Interdisciplinary Connections. Incorporating interdisciplinary projectsfor example, integrating mathematics with environmental sciencecan increase the real-world relevance of learning tasks and promote sustained student participation and motivation across subject areas.

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