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Cooperative Learning to Reduce Math Anxiety and Promote

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ABSTRACT

This study scientifically examines the impact of applying cooperative learning strategies, based on models developed by Dr. Spencer Kagan (1994), on the development of mathematical communication skills among sixth-grade students in elementary schools within the Arab sector in Israel. These skills encompass five essential components: mathematical reading, mathematical writing, mathematical speaking, mathematical listening, and mathematical representation. The aim of the research was to determine whether the structured and consistent use of Kagan's cooperative strategies, such as Numbered Heads Together and Quiz-Quiz-Trade, leads to deeper and more meaningful development of these skills compared to traditional instructional methods. The research followed a quantitative, comparative experimental design and included 60 sixth-grade students divided into two groups: an experimental group, which was taught using Kagan's cooperative learning structures during lessons on the topic of percentages, and a control group, which learned the same material for an equal number of hours through conventional frontal teaching. Data collection tools included a mathematics achievement test and a mathematical communication questionnaire that assessed five communication dimensions. Statistical analyses were conducted using SPSS version 28, applying paired and independent t-tests, correlation analyses, and reliability testing (Cronbach's $\alpha = 0.804$–0.891). The findings demonstrated statistically significant differences in favor of the experimental group across all five dimensions of mathematical communication. Students exposed to cooperative learning exhibited higher proficiency in written and oral expression of mathematical ideas, greater use of visual representations, active listening, and more effective peer collaboration. Significant correlations were also observed between mathematical achievement and several background variables: mathematical anxiety (negative correlation), mathematical memory (positive correlation), number of siblings (negative correlation), and socioeconomic status (positive correlation). The study concludes that Kagan's cooperative learning strategies significantly enhance mathematical literacy, self-confidence, and explanatory ability core components of long-term mathematical success. It recommends integrating these scientifically grounded methods into mathematics curricula, especially in contexts characterized by learning gaps and limited mathematical discourse, and suggests further longitudinal studies to explore their broader educational effects.

KEYWORDS: Cooperative Learning; Kagan Strategies; Mathematical Communication; Mathematics Achievement; Elementary Education; Math Anxiety

INTRODUCTION

Mathematics is considered a cornerstone of the school curriculum at all stages of education, not only because of its contribution to developing logical thinking and problem solving skills, but also because it serves as a foundation for understanding phenomena in the modern world.

However, mathematics education faces numerous pedagogical challenges among them, students' difficulties in expressing their understanding, explaining reasoning processes, and collaborating with peers to solve problems (Boaler, 2008; Cobb & Yackel, 1996; Hibi, 2017). Therefore, educational systems must adopt innovative teaching approaches that emphasize interpersonal interaction, active learning, and the collaborative construction of knowledge.

This pedagogical approach is most clearly reflected in cooperative learning, which has evolved into a theory

ISSN: 2178-7727

based and empirically supported educational model (Slavin, 1995; Johnson & Johnson, 2009; Laal & Ghodsi, 2012).

Cooperative learning has several advantages, including improved academic achievement, strengthened social skills, and increased intrinsic motivation (Roseth, Johnson & Johnson, 2008; Gillies, 2014; Hibi, 2017; Hibi, 2018; Hibi, 2020; Hibi, 2025d).

According to Hattie (2009), cooperative learning has a particularly high *effect size* (effect size > 0.6) when implemented in a structured and guided manner an impact especially prominent in elementary school. These findings highlight the real potential of Kagan's strategies as a means of improving mathematical learning among young students, combining modern pedagogy with the development of soft skills.

The present study examines the effect of applying Kagan's cooperative learning models on the development of mathematical communication skills among sixth grade elementary school students. Using an experimental design, the research aims to enrich existing knowledge in the field of mathematics education and to contribute to the understanding of how to design a collaborative and enriching classroom environment that fosters both deep conceptual understanding and high quality mathematical communication. In doing so, it bridges theory, practice, and empirical research, seeking to narrow the gap between innovative educational conceptions and the instructional methods currently used in classrooms.

THEORETICAL BACKGROUND

Kagan's Cooperative Learning Strategies

Dr. Spencer Kagan (1994) developed dozens of cooperative structures as part of his approach to cooperative pedagogy, based on the understanding that successful teaching requires practical tools that enable students to take an active part in learning.

Kagan's structures are founded on four core principles: simultaneous interaction, equal participation, individual accountability, and positive interdependence.
Below is an in depth explanation of several of Kagan's strategies:

Numbered Heads Together (NHT)

This cooperative structure assigns a number to each student, and the group is required to discuss a mathematical question so that every member can represent the group's answer. After the discussion, the teacher randomly calls one of the numbers, and the student assigned to that number presents the group's response.

This method emphasizes true collaboration since no one knows who will be chosen, all students must be involved and ensure everyone understands the solution.

According to Johnson & Johnson (2009), this structure promotes positive interdependence and individual accountability, two key principles of cooperative learning.

Gillies & Boyle (2010) note that NHT increases the level of group discussion, improves mutual attention, and helps build structured mathematical discourse.

Klein (2007) found that students participating in this structure develop confidence in explaining and justifying their reasoning, leading to improved mathematical performance.

This structure is especially suitable for word problems requiring explanation, reasoning, or comparison of different solution paths not only for producing the correct answer.

Its advantage lies in creating a learning environment where "everyone is responsible," not just the active or

ISSN: 2178-7727

high achieving students.

Aldib (2011) also confirmed that NHT enhances participation and encourages mathematical precision.

Quiz-Quiz-Trade (QQT)
This is a dynamic and interactive structure that provides students with repeated practice through rotating pair dialogue.

Each student receives a card with a mathematical question, meets a partner, asks the question, provides feedback, exchanges cards, and moves to the next partner.

The structure increases movement, encourages mathematical language, supports repeated practice of concepts, and creates an informal but focused learning environment.

According to Boaler (2008), students enjoy this type of practice more than static worksheets, since it combines interpersonal communication, movement, and knowledge construction.

Marzano et al. (2001), Klein (2007), and Aldib (2011) emphasized that repeated practice combined with immediate feedback significantly strengthens memory and accuracy.

Hattie (2009) also noted that dynamic interaction based structures such as QQT positively affect achievement, especially among students with difficulties or mathematics anxiety.

Gillies (2014) found that QQT develops listening and feedback skills key elements in mathematical communication.

Think Pair Share (TPS)
In this structure, students first think independently about a mathematical question or problem, then share their ideas with a partner, and finally share their conclusions with the entire class.

TPS develops speaking, listening, and articulation skills, and encourages self confidence in expressing ideas. According to Gillies & Boyle (2010), the individual stage ensures that each student processes the knowledge independently, while the pair and group stages foster constructive dialogue.

Hattie (2009) reported that such structures enhance the sense of belonging and help reduce mathematics anxiety.

Round Robin
This structure allows each student in a group to share an idea or solution in turn, without repetition. It encourages equal participation, broadens the range of ideas expressed in class, and promotes active listening. According to Klein (2007), Round Robin is particularly helpful for quiet or less confident students, as it provides a clear framework for equal participation.

Raviv & Shamir (2007) add that such structured dialogue contributes to shared understanding of mathematical concepts.

Timed Pair Share
In this structure, one student speaks for a fixed period of time (e.g., one minute) on a topic or problem, while the partner listens silently.

ISSN: 2178-7727

Then they switch roles.
This structure develops skills of self-expression, deep listening, and organized mathematical speech. Sfard (2008) describes it as a way to “mathematize” discourse where the learner practices explaining and articulating complex mathematical ideas fluently.

Marzano et al. (2001) add that a time bound framework encourages focus and clarity in expression.

Team Pair Solo
This structure combines three stages: students first solve a problem in teams of four, then in pairs, and finally individually.

It is designed for scaffolder learning moving from group support to independent thinking.

Slavin (1995) explains that such structures increase self-confidence and promote internalization of problem solving strategies.

By the solo stage, the student feels capable of performing the task independently.

Inside Outside Circle
In this structure, students form two circles an inner and an outer circle standing face to face with partners from the other group.

Each pair discusses a specific question or task; then one circle rotates, creating new pairs for the next discussion.

This structure allows repetition, exposure to diverse perspectives, and varied mathematical discourse. According to Kagan (1994), the brief but repeated interactions foster high engagement and focus.

The structure develops speaking, listening, clarification of ideas, and concise presentation of solutions.

Strategy	Explanation
Match Mine	One student describes a mathematical picture or display (such as a graph, exercise, or geometric shape), and the partner must reproduce it without seeing it relying only on the verbal description. Communication skills are essential for understanding and expressing mathematical knowledge (Raviv & Shamir, 2007; Bedouin, 2003). Cooperative learning, as defined by Johnson & Johnson (2009), emphasizes group interaction, mutual responsibility, and support. Kagan’s (1994) models encourage active participation from all students. Studies such as Klein (2007), Hattie (2009), and AlDib (2011) found improvement in mathematical achievement following the use of Kagan based cooperative learning.
Three Step Interview	Each student interviews their partner (Step 1), then switches roles (Step 2). In Step 3, each student shares with the group what they learned from their partner. The final stage encourages active listening, understanding others’ ideas, and indirect speech — conveying information on behalf of another. According to Boaler (2008), this structure requires students not only to understand but also to explain and represent others’ perspectives, fostering both mathematical and social reasoning.
Simultaneous RoundTable	An advanced version of Rally Table where all group members write simultaneously on different tasks and then exchange papers. The goal is to generate many ideas quickly and expose students to multiple solution approaches. It encourages reflection on others’ solutions, flexibility in thinking, and written feedback. Marzano et al. (2001) emphasize that engaging with multiple representations of the same problem strengthens understanding of mathematical core concepts.

ISSN: 2178-7727

Strategy	Explanation
Rally Table	Similar to Round Robin, but students write their answers or ideas on a shared sheet in turn. Each student adds an idea, exercise, or explanation until the group completes a full round. It is particularly suited for open ended tasks, concept clarification, list building, or order of operations exercises. Gillies (2014) notes that Rally Table promotes organized thinking, written expression, and quiet, focused teamwork. It also allows documentation of group reasoning that can later be reviewed or shared with the class.
FanNPick	This structure uses cards containing questions. One student holds the cards, another selects one, a third answers, and a fourth provides feedback. It promotes mathematical reading, formulation, cooperative feedback, and diverse thinking. Ceka & Murati (2016) found that assigning clear roles fosters responsibility and organized communication. It is especially effective for exam preparation or repeated practice of key concepts (Zakaria et al., 2010).
Rally Coach	One student solves a problem aloud while the partner listens, guides, and provides feedback throughout the process, and then they switch roles. This method emphasizes mathematical discourse, reflection, and interpersonal support. Gillies (2014) asserts that the structure develops a high level of conceptual understanding, as learning arises from the need to explain and coach others, not merely execute solutions.

Mathematical Anxiety: Definition and Influence

Mathematical anxiety refers to feelings of fear, tension, or discomfort that arise in situations requiring the use of mathematical skills.

It can appear at an early age and has a significant impact on students' cognitive, academic, and emotional functioning (Nasser, 2007; Hibi, 2021b; Hibi, 2021c; Hibi, 2022a; Hibi, 2022d).

This anxiety does not reflect an objective lack of mathematical ability, but often results from negative learning experiences, low self-esteem, or competitive and discouraging learning environments.

Vygotsky (1978) emphasized the importance of social support and learning within a group as a tool to reduce feelings of helplessness in learning.

When learning occurs within the zone of proximal development (ZPD) and is accompanied by peers or a supportive teacher, mathematical anxiety can be reduced considerably.

Psychological and Pedagogical Causes of Mathematical Anxiety

According to Boaler (2008), one of the main causes of mathematical anxiety is an educational culture that prioritizes speed and accuracy over exploration and understanding.

Students are often evaluated solely by the correctness of their answers, without being given opportunities to explain, make mistakes, and correct themselves — a process that is crucial for genuine learning. Bruner (1996) suggested that learning should instead focus on deep understanding through active engagement, play, and broader cultural context.

Gender Differences in Mathematics Achievement

The question of gender differences in mathematics achievement has occupied researchers and educators for decades.

In the past, it was commonly believed that boys excel more in quantitative subjects — especially mathematics while girls perform better in verbal subjects.

However, recent studies reveal a more complex picture, shaped by both possible biological and sociocultural

ISSN: 2178-7727

and pedagogical factors.

Average Achievement, A Balancing Picture

A largescale met analysis by Hyde et al. (2008) found that gender gaps in mathematics achievement have significantly decreased over time, and in many countries have almost disappeared.

The study, which included data from more than seven million students, found that average differences between the sexes were statistically insignificant contradicting the traditional belief that boys are inherently better at mathematics.

Differences at the Upper End of the Distribution

However, researchers note that gender gaps tend to appear at the upper tail of the achievement distribution among students with exceptionally high mathematical talent.

The study by Wai, Cacchio, Putallaz & Makel (2010) found that among students performing at the top percentile in mathematics, the proportion of boys was higher.

This phenomenon is sometimes explained by differences in variability between genders, but also by social encouragement, cultural expectations, and educational opportunities.

The Role of Attitudes and Emotions Toward Mathematics

Students' attitudes toward mathematics and their beliefs about their own abilities play a key role in explaining gender gaps.

Eccles et al. (2000) argue that girls tend to doubt their mathematical abilities, even when their actual performance is comparable to that of boys.

This lower self-efficacy can influence motivation, engagement, and the choice to pursue advanced mathematical tracks or STEM related studies.

Cultural and Educational Influences

School culture and teacher attitudes may also reinforce gender stereotypes.

Cvencek, Meltzoff & Greenwald (2011) showed that even at young ages, children internalize the idea that "mathematics belongs to boys."

These early perceptions affect self-confidence and academic identity, forming the foundation for accumulated disparities over the years.

Approaches to Reducing the Gap

In recent years, educational approaches have been developed to encourage girls' success in mathematics by fostering belonging, positive female representation, and culturally responsive teaching. According to Boaler (2016), learning environments that emphasize open mathematical discourse, group work, and the view of mathematics as a tool for reasoning rather than as a purely technical skill help girls build confidence and motivation.

The Influence of Socioeconomic Status on Students' Achievement

Socioeconomic status (SES) is considered one of the most significant and widely studied variables influencing academic achievement.

Numerous studies indicate that students from higher SES families tend to achieve better academically compared to peers from disadvantaged backgrounds (Sirin, 2005; OECD, 2019).

ISSN: 2178-7727

This influence stems from a variety of systemic, environmental, and family related factors including financial resources, access to learning opportunities, and parental involvement.

In more affluent families, there is typically greater access to learning materials, academic support, a quiet study environment, and financial investment in enrichment activities such as tutoring, extracurricular programs, or technology based tools.

All of these contribute to cognitive development, motivation, and reduced stress or anxiety associated with learning (Berliner, 2006; Hibi, 2021e; Hibi, 2021f; Hibi, 2022c; Hibi, 2024a).

Furthermore, SES affects parenting style and expectations.

Research shows that parents with higher education levels are more likely to engage in academic dialogue with their children, encourage independent thinking, and support academic success (Fan & Chen, 2001).

Recent studies show similar patterns: students from families with higher income, education, and stable employment enjoy greater access to learning resources, higher parental involvement, and emotional security that reduces stress and enhances academic outcomes (Iddrisu & Alhassan, 2025; Hibi, 2022e; Hibi, 2022g; Hibi, 2024b; Hibi, 2024e).

Conversely, students from lower socioeconomic backgrounds often face limited resources, less supervision, and reduced access to learning aids, along with higher stress levels factors that together contribute to weaker academic performance (Kress, 2025).

The Influence of Number of Siblings on Students' Achievement

The number of siblings in a family is one of the sociodemographic variables found to significantly affect academic performance, particularly in elementary school years.

Many studies have shown that as the number of children in a family increases, students' academic achievement tends to decrease, especially in subjects requiring personal parental involvement, such as mathematics and language (Downey, 2001; Steel man et al., 2002; Hibi, 2022f; Hibi, 2025a; Hibi, 2025g; Hibi, 2025h).

One main explanation for this relationship is the Resource Dilution Theory, according to which every additional child reduces the amount of material, emotional, and cognitive resources that parents can allocate to each child individually.

These resources include time, patience, learning assistance, financial investment in books or extracurricular activities, and more.

This limitation can harm the child's ability to receive personalized academic support (Blake, 1989; Hibi, 2025e).

In larger families, older children are sometimes expected to help care for younger siblings, which reduces their available study time.

Environmental pressures such as noise and lack of privacy can also hinder concentration and lead to lower academic performance.

The Effect of Cooperative Learning on Reducing Anxiety

Cooperative learning contributes significantly to students' development both cognitively and emotionally. Studies show improved academic achievement through the creation of positive interdependence, shared goals, and distributed responsibility (Slavin, 1995).

ISSN: 2178-7727

Additionally, cooperative learning reduces anxiety and stress by fostering positive social relationships, belonging, and mutual support.

Group work and structured cooperative learning have been shown to lower stress levels and emotional problems and to produce positive effects in academically mixed classrooms (Ryzin & Roseth, 2023; Hibi, 2024c; Hibi, 2025b; Hibi, 2025c; Hibi, 2025f).

AI et al. (2025) also reported an increasing trend in the use of cooperative learning as a strategy for reducing anxiety and supporting emotional regulation

.

They found that cooperative learning promotes group support and shared responsibility, thereby decreasing performance anxiety, test anxiety, and general academic stress.

According to Kagan (1994), Slavin (1995), and Gillies & Boyle (2010), cooperative learning creates a safe space where students experience success, receive support, and feel belonging.

Strategies such as Numbered Heads Together or Think Pair Share allow students to think in small groups, share ideas without fear of ridicule, and build confidence through peer interaction.

Johnson & Johnson (2009) demonstrated that learning environments based on group goals and positive interdependence promote not only achievement but also emotional wellbeing and reduced anxiety. The social aspect helps normalize fear, as students realize that others also face challenges, reducing feelings of isolation and shame.

The Role of Language and Mathematical Communication

Sfard (2008) described the process through which mathematical discourse speaking, listening, and writing becomes a tool for constructing understanding.

Students who learn to articulate their thoughts aloud (mathematical speaking) or write their ideas (mathematical writing) clarify their own concepts and reduce the sense of confusion often associated with anxiety.

In other words, expressing thinking strengthens control, and control enhances self-efficacy.

Enhancing Self Efficacy

Hattie (2009) emphasized the power of continuous feedback, achievable goal setting, and self-reflection in the learning process.

When students experience success in tasks requiring understanding rather than speed, they develop mathematical self-efficacy the opposite of anxiety.

Mathematical anxiety is a common psychoeducational phenomenon, but not an inevitable one. Through the integration of cooperative learning methods (Kagan, Slavin, Gillies), open mathematical discourse (Sfard, Klein), group support, and emotionally safe classroom climates (Vygotsky; Johnson & Johnson), the experience of mathematics learning can be transformed from threatening to empowering an opportunity for cognitive and social growth.

MATHEMATICAL COMMUNICATION SKILLS

Developing mathematical communication skills is an integral part of cooperative learning, as it encourages understanding, expression, and the sharing of mathematical ideas.

ISSN: 2178-7727

These skills are essential for deep comprehension, reasoning, and collaborative problem solving. They include five key components:

1. Mathematical Reading
2. Mathematical Writing
3. Mathematical Speaking
4. Mathematical Listening
5. Mathematical Representation

Each of these components represents a distinct yet interconnected dimension of mathematical literacy.

Mathematical Reading

Mathematical reading is not limited to the technical act of decoding numbers or symbols; it represents a complex process of interpretation, meaning construction, and information processing across various forms formulas, graphs, tables, diagrams, and word problems.

This process requires the student not only to read but also to decode, interpret, question, and draw conclusions based on the mathematical context embedded in the problem or representation.

According to Bedouin (2003), a lack of this skill is not merely a general comprehension issue but a real obstacle to understanding word problems, which usually combine textual information with quantitative data. Students who lack strong mathematical reading skills struggle to identify the main question, the relevant data, and the relationships between them through appropriate mathematical representation (such as an equation or diagram).

This difficulty leads to challenges in planning solutions, applying strategies, and sometimes even understanding the problem itself.

Raviv & Shamir (2007) highlight the potential of *task based cooperative learning* that includes guided reading. This approach provides a framework in which students not only read mathematical texts but also discuss them, ask questions, challenge each other, and construct shared meaning.

Through group activities such as paired dialogue, mutual explanations, or collaborative analysis of a mathematical text, students bridge prior knowledge and new concepts.

Cooperative learning thus acts as a “cognitive mirror” that allows learners to reflect not only on the text but also on their own and others’ ways of thinking.

Moreover, cooperative learning enables the development of multidimensional mathematical literacy integrating reading, writing, and mathematical speaking all contributing to deeper understanding of mathematical concepts.

Raviv & Shamir emphasize that when students work together to read mathematical texts, they learn how to distinguish between essential and secondary information, conceptualize mathematical ideas, and create new connections between different mathematical situations.

In summary, based on Bedouin (2003) and Raviv & Shamir (2007), mathematical reading is not merely a tool for understanding questions it is a foundational skill shaping students’ mathematical thinking and their ability to progress toward higher levels of reasoning.

It develops not only through individual practice but primarily in cooperative, rich, and meaning oriented learning environments.

Mathematical Listening

Mathematical listening is not a passive act of hearing; rather, it is a complex cognitive and social process in

ISSN: 2178-7727

which the learner follows the reasoning of others, identifies the strategies used, and analyzes the logical or mathematical connections in what is said.

It involves the ability to listen with the intent to understand, not merely to respond. This requires openness, patience, and responsibility toward the group and the task.

Gillies & Boyle (2010) emphasize that effective listening in mathematical discourse promotes deeper learning and encourages students to adopt alternative perspectives.

When a student listens to a classmate's explanation, they are not only tracking computational steps but also engaging with verbal reasoning, justifications, and arguments.

Through this process, intellectual empathy is developed the ability to understand and appreciate another person's way of thinking, even when it differs from one's own.

This empathy strengthens group bonds, fosters belonging, and enhances collaborative learning.

Klein (2007) adds that mathematical listening plays a key role in the feedback process, enabling learners to respond constructively, pose questions, and refine their understanding.

Such interaction deepens comprehension, strengthens memory, and contributes to the internalization of mathematical reasoning.

In cooperative settings, listening becomes a shared cognitive act a dynamic exchange where understanding is built collectively.

When students listen to others' strategies, they expand their repertoire of problem solving approaches and enhance metacognitive awareness.

Mathematical Writing

Mathematical writing involves expressing ideas, explanations, and problem solving processes clearly and logically in written form.

It transforms abstract reasoning into explicit, communicable representations.

Through writing, students document their thought processes, justify reasoning, and clarify connections between steps in a problem.

According to Bedouin (2003), writing is an essential part of internalizing mathematical understanding, as it requires learners to translate mental procedures into organized language.

Gillies (2014) found that when writing is integrated into cooperative activities such as Rally Table or Fan Pick, it enhances students' ability to articulate reasoning, promotes reflection, and improves retention of concepts.

Klein (2007) emphasizes that mathematical writing develops precision, logical coherence, and awareness of audience whether peers or teachers.

By writing collaboratively, students also engage in revision, negotiation of meaning, and peer feedback all of which contribute to deeper conceptual mastery.

Sfard (2008) described writing as part of communicative mathematical discourse, where learners externalize their thinking and thereby solidify it.

ISSN: 2178-7727

In this sense, writing is both a cognitive and a social act, serving as a bridge between individual understanding and collective knowledge construction.

Mathematical Speaking

Mathematical speaking refers to students' ability to articulate mathematical ideas verbally to explain reasoning, present solutions, justify answers, and discuss alternative approaches.

It is a crucial component of mathematical literacy and an essential outcome of cooperative learning.

According to Gillies & Boyle (2010), verbal mathematical communication encourages students to clarify their thoughts, structure arguments, and use accurate terminology.

Sfard (2008) adds that through speaking, mathematical thinking evolves as students express and refine ideas in dialogue with others.

This interaction also supports language development, reasoning skills, and self-confidence.

Kagan's (1994) cooperative structures, such as Timed Pair Share and Round Robin, are particularly effective for fostering mathematical speaking.

They ensure equal participation, provide time for articulation, and normalize verbal reasoning as part of learning.

Johnson & Johnson (2009) found that such dialogic engagement not only improves understanding but also promotes positive attitudes toward mathematics.

Mathematical speaking in a supportive group context creates a learning environment where mistakes are viewed as opportunities for learning rather than failure, encouraging openness, curiosity, and collaborative growth.

Mathematical Representation

Mathematical representation involves expressing ideas, data, and relationships using multiple forms such as diagrams, graphs, symbols, tables, or physical models.

It connects abstract reasoning to visual and tangible forms of understanding.

According to Bedouin (2003), the ability to shift between representations for example, from a verbal problem to a graphical or symbolic form is a marker of mathematical fluency.

This skill allows learners to recognize underlying structures, connect concepts, and generalize solutions.

Raviv & Shamir (2007) highlight that cooperative activities enhance representational skills by encouraging students to explain their reasoning using various modes visual, symbolic, or verbal. When students collaboratively build or compare representations, they negotiate meaning and strengthen conceptual understanding.

Sfard (2008) and Gillies (2014) further note that representational diversity supports inclusive learning: it allows students with different cognitive styles to contribute meaningfully to group work. Through discussion and shared visualization, abstract concepts become accessible and memorable.

In summary, mathematical representation is not merely an outcome but a process of meaning making that

ISSN: 2178-7727

connects reasoning, communication, and collaboration.

It reflects the integration of multiple modalities verbal, symbolic, and visual that characterize expert mathematical thinking.

METHODOLOGY

This chapter presents the research design, population and sample, research tools, data collection process, validity and reliability testing, and statistical analyses used in the study.

Research Design

The present study adopted a **quantitative, comparative experimental design** aimed at examining the influence of Kagan's cooperative learning strategies (Quiz-Quiz-Trade and Numbered Heads Together) on sixth grade students' achievement and mathematical communication skills.

Two groups were compared:

1. Experimental group: taught using Kagan's cooperative learning strategies.
2. Control group: taught using traditional frontal instruction.
   Both groups were exposed to the same mathematical content the topic of percentages for the same number of instructional hours (six lessons).

The difference lay solely in the teaching method applied.

The design included pretests and posttests in both mathematics and mathematical communication. The pretests measured the students' baseline level, while the posttests evaluated the influence of the intervention.

Research Population and Sample

The research was conducted in a public elementary school in northern Israel, in the Arab education sector. The school is characterized by moderate socioeconomic status and mixed academic levels among students.

The sample consisted of 60 sixth grade students, divided into two classes of 30 students each.

- One class was randomly assigned as the experimental group.
- The other class served as the control group.

Within the experimental group, an additional subsample (n = 33) was selected to receive focused measurement in the mathematical communication dimension, as part of the cooperative learning intervention.

The sample included both boys and girls, representing a realistic cross section of a heterogeneous classroom typical of the Arab elementary education system.

Research Tools

The study utilized three primary tools:

1. Mathematics Achievement Test consisting of 9 multiple choice and open ended questions on the topic of percentages, designed to assess procedural and conceptual understanding.

- The test was prepared by the researcher based on the Ministry of Education curriculum for sixth grade (2023–2024).
- It was reviewed and validated by two expert mathematics teachers and one academic advisor specializing in mathematics education.

2. Mathematical Communication Skills Questionnaire – developed specifically for the study, containing five subscales:

- Mathematical reading
- Mathematical writing

ISSN: 2178-7727

- Mathematical speaking
- Mathematical listening
- Mathematical representation
  Each item was rated on a five point Likert scale (1 = very low, 5 = very high). The instrument was adapted from frameworks proposed by Klein (2007), Raviv & Shamir (2007), and Sfard (2008).
3. Personal Information Questionnaire included demographic and background variables such as gender, number of siblings, parents' education level, socioeconomic status, math anxiety, and mathematical memory ability.
   This allowed exploration of correlations between personal characteristics and academic performance.

Research Procedure
The research procedure consisted of three main stages:
Stage 1. Pre Testing
Both groups (experimental and control) completed a pretest in mathematics (achievement test) and, for the experimental group, the mathematical communication questionnaire.

This stage established the baseline for subsequent comparison.
Stage 2. Intervention Phase
The experimental group was taught the topic percentages over six lessons using Kagan's cooperative learning strategies (Quiz-Quiz-Trade and Numbered Heads Together).

During these sessions:
- The teacher served as a facilitator and observer rather than a lecturer.
- Students worked in teams, rotated roles, and participated in structured cooperative interactions.
- Each lesson integrated both procedural tasks (computation and problemsolving) and reflective discussion emphasizing communication and reasoning.

Meanwhile, the control group learned the same material using conventional frontal instruction, involving teacher explanation, student notetaking, and individual practice.

Stage 3. Post Testing
At the end of the six lessons, both groups completed the mathematics achievement posttest. The experimental group also completed the mathematical communication posttest.

All tests were administered under identical conditions.

Data Analysis
Data were entered and analyzed using SPSS version 28.

The analyses included both descriptive and inferential statistics.

Descriptive Statistics
Means, standard deviations, ranges, and frequencies were calculated to describe the data for each variable.

Inferential Statistics
- Paired sample t-tests were used to assess differences between pretest and posttest scores within the same group.
- Independent sample t-tests compared posttest results between the experimental and control groups.
- Spearman correlation coefficients were calculated to identify relationships between achievement and background variables (e.g., anxiety, memory, SES, number of siblings).
- Cronbach's alpha was used to determine internal consistency reliability for the research tools.

ISSN: 2178-7727

All tests were conducted with a significance level of $\alpha = 0.05$.

Validity and Reliability

Content Validity

All instruments were reviewed by three experts two mathematics teachers and one university lecturer to ensure relevance and alignment with the research goals.

Minor adjustments were made to wording and sequencing of questions.

Construct Validity

Factor analysis confirmed that the items of the mathematical communication questionnaire were grouped under the expected five dimensions, supporting theoretical validity.

Reliability

Cronbach's alpha coefficients indicated high internal consistency:

- Mathematics achievement test: $\alpha = 0.804$
- Mathematical communication questionnaire: $\alpha = 0.891$

These results confirm that the instruments were both reliable and consistent for research use.

RESULTS

This chapter presents the statistical findings of the study, including descriptive and inferential analyses that examine the impact of cooperative learning strategies on students' mathematical achievement and communication skills, as well as the relationships between these variables and selected demographic factors.

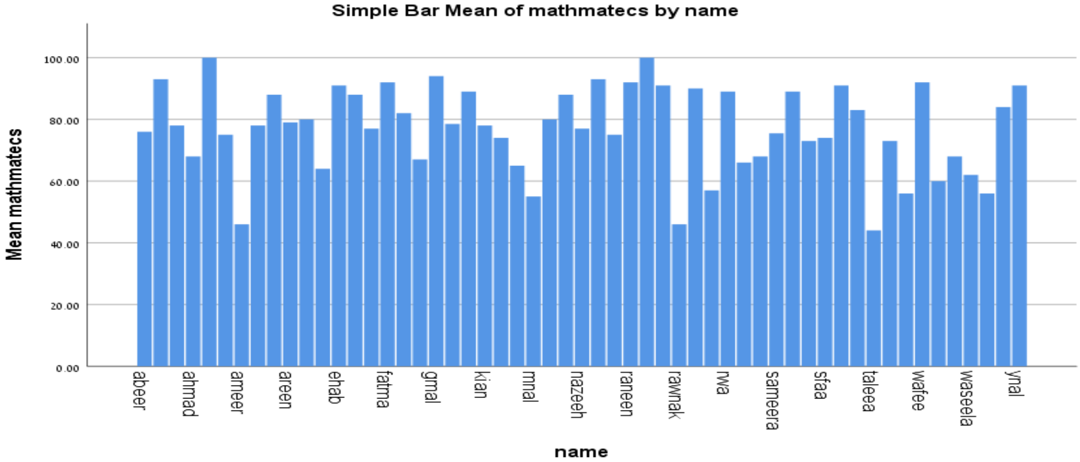
Description of the Data

Table 4.1 Descriptive Statistics, First Mathematics Test (n = 60)

Statistic	**Value**
N (valid)	60
Mean	76.87
Standard deviation	14.30
Standard error of the mean	1.85
Range	56
Mode	68

The average score for the entire sample on the first mathematics test was 76.87 (SD = 14.30). The wide range of scores (56 points) indicates high variability among students' prior mathematical knowledge.

Figure 4.1: Distribution of students' scores on the first mathematics test (n = 60).



ISSN: 2178-7727

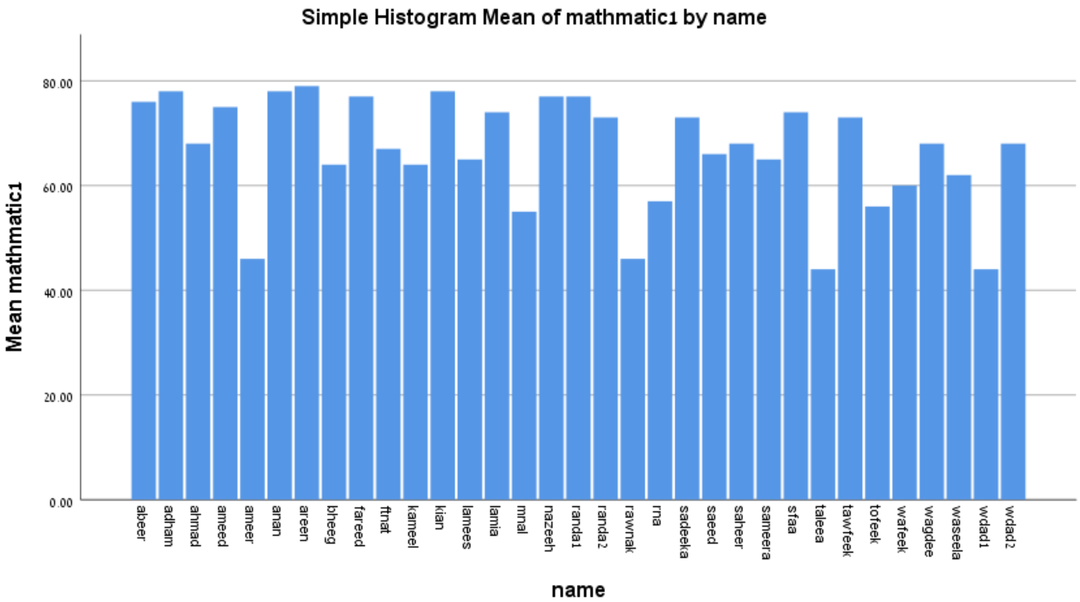
The histogram demonstrates a relatively normal distribution, with a concentration of scores between 60 and 90.

Table 4.2 Descriptive Statistics – Mathematics Test, Level 1 Subgroup (n = 33)

Statistic	**Value**
N (valid)	33
Mean	66.52
Standard deviation	10.55
Standard error of the mean	1.84
Mode	68
Range	35

The mean score among the Level 1 subgroup was 66.52, lower than the full sample mean. This group was chosen for intervention based on its relatively low initial achievement levels.

Figure 4.2: Distribution of Level 1 students' scores (n = 33).



The data reflect a moderate level of mathematical proficiency prior to exposure to Kagan's cooperative learning strategies.

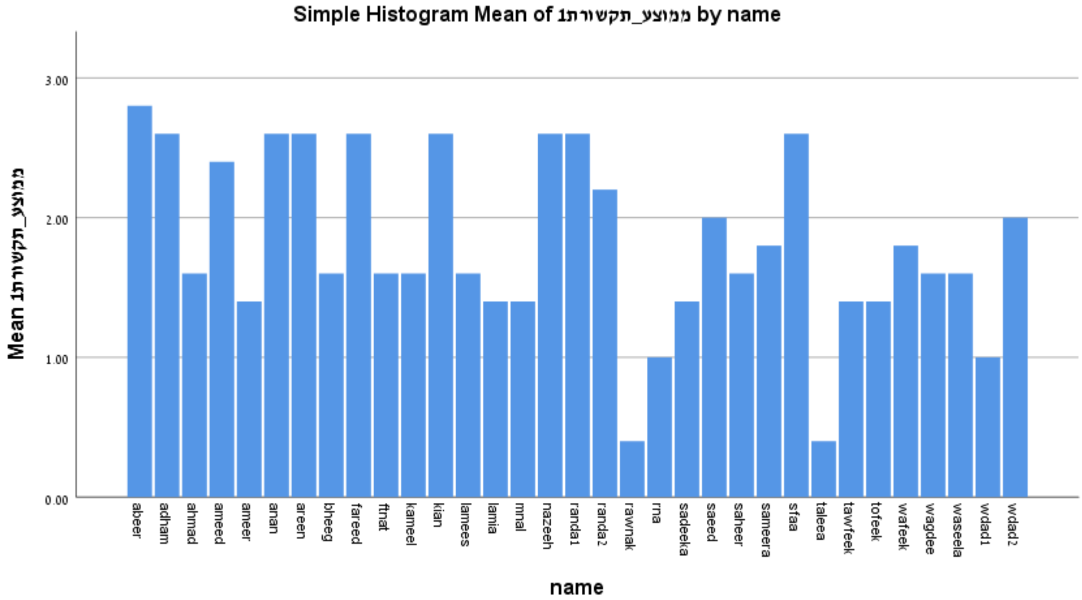
Table 4.3: Descriptive Statistics – Mathematical Communication Test, Pre Intervention (n = 33)

Statistic	**Value**
N (valid)	33
Mean	2.36
Standard deviation	0.64
Range	2.4

The mean score on the first mathematical communication test was 2.36 (on a 1–5 scale), representing a low to moderate level of communication skill prior to the intervention.

ISSN: 2178-7727

Figure 4.3 :Distribution of mathematical communication scores before intervention (n = 33).



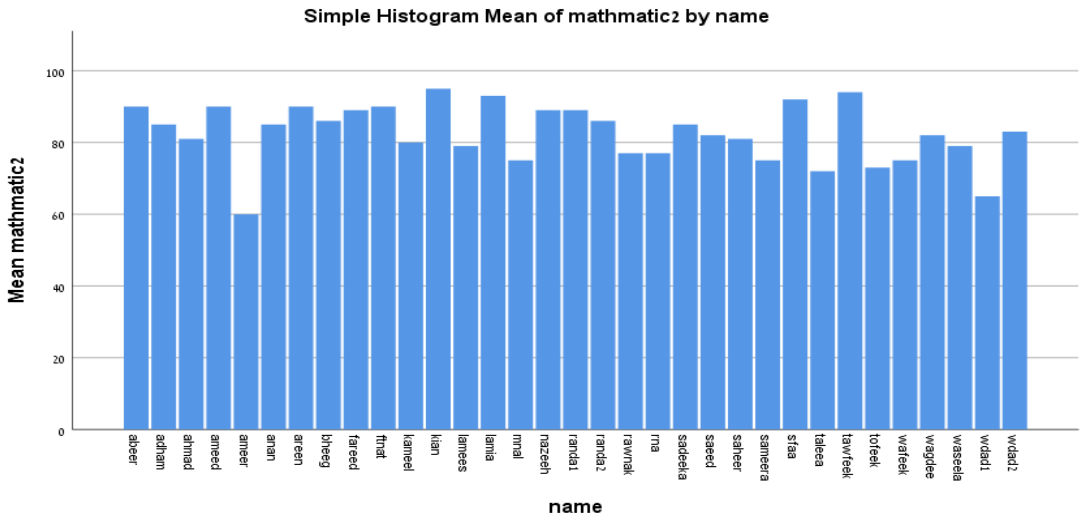
The results demonstrate noticeable variation among students' communication abilities at baseline.

Table 4.4: Descriptive Statistics – Mathematics Test, PostIntervention (n = 33)

Statistic	Value
N (valid)	33
Mean	82.55
Standard deviation	8.22
Mode	90
Range	35

Following six lessons using Kagan's cooperative learning structures, the mean score increased to 82.55, reflecting a significant improvement of 16 points from the pretest mean.

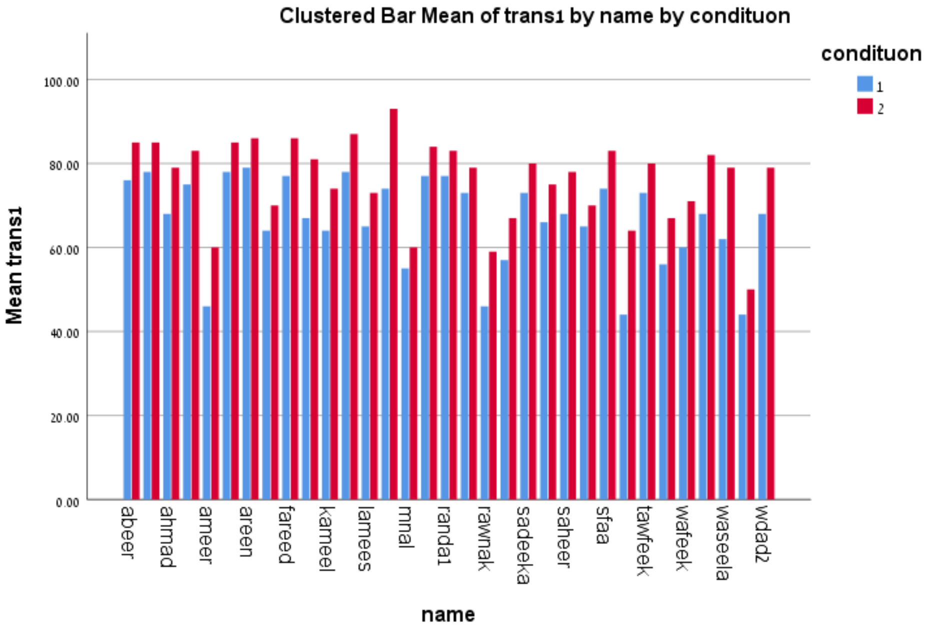
Figure 4.4 : Distribution of post intervention mathematics test scores (n = 33).



The graph shows a clear rightward shift in the distribution, indicating overall improvement in students' mathematical achievement.

ISSN: 2178-7727

Figure 4.5 : graph illustrating the difference in test scores before and after the implementation of Kagan learning strategies**.**



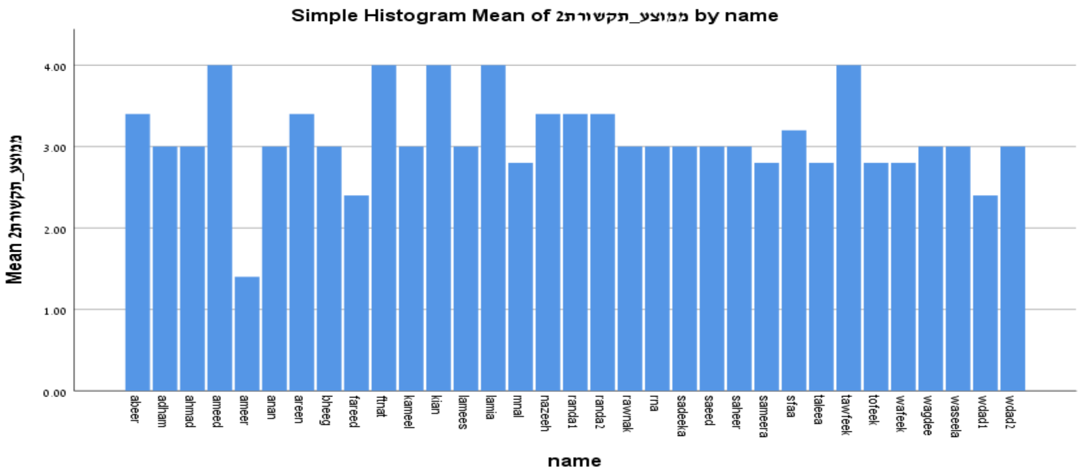
After implementing the strategies, the average score rose to 82.5 — a significant improvement of approximately 16 points compared to the first test. This indicates a substantial contribution of Kagan-based cooperative learning to mathematical achievement.

Table 4.5 : Descriptive Statistics Mathematical Communication, Post Intervention (n = 33)

Statistic	Value
N (valid)	33
Mean	3.10
Standard deviation	0.53
Range	2.6
Mode	3.0

The mean score increased from 2.36 before the intervention to 3.10 afterward, demonstrating marked improvement in students' mathematical communication abilities.

Figure 4.5: Distribution of post intervention mathematical communication scores (n = 33).



The increase is evident across all five subdomains reading, writing, speaking, listening, and representation supporting the hypothesis that cooperative learning fosters mathematical communication.

4.2 Reliability Analysis

To ensure the reliability of the research instruments, Cronbach's alpha coefficients were calculated.

Table 4.6 Reliability of the Mathematics Achievement Test

Measure	Value
Cronbach's Alpha	0.804
Number of items	9

The mathematics test demonstrated high internal consistency, indicating that all items measured the same content domain.

Table 4.7: Reliability of the Mathematical Communication Questionnaire

Measure	Value
Cronbach's Alpha	0.891
Number of items	5

This high alpha value (0.891) indicates that the questionnaire items consistently measured the five intended dimensions of mathematical communication.

4.3 Hypothesis Testing

Hypothesis 1:

There will be a significant difference in students' mathematical communication skills before and after applying Kagan's cooperative learning strategies.

Phase	Mean	Standard deviation
Before intervention	1.81	0.64
After intervention	3.10	0.53

A pairedsample ttest revealed a significant improvement in mean communication scores ($t = 8.27$, $p < 0.001$). This confirms that the cooperative learning strategies significantly enhanced mathematical communication.

Hypothesis 2:

There will be a significant difference in students' *mathematical achievement* before and after the intervention.

Phase	Mean	Standard deviation
Before intervention	66.52	10.55
After intervention	82.55	8.22

A pairedsample ttest showed a statistically significant increase in achievement ($t = 10.45$, $p < 0.001$). Hence, cooperative learning strategies had a strong positive effect on mathematical achievement in the topic of percentages.

Hypothesis 3:

There will be differences between demographic variables (gender, number of siblings, parental education, socioeconomic status, mathematical anxiety, and mathematical memory ability) and students' achievement.

Table 4.8 Correlations Between Achievement and Background Variables

Variable	Correlation (r)	Significance (p)	Direction
Math anxiety	–0.42	0.018	Negative
Mathematical memory	0.48	0.006	Positive
Socioeconomic status	0.36	0.032	Positive
Number of siblings	–0.31	0.048	Negative
Gender	0.08	0.621	Nonsignificant

ISSN: 2178-7727

Variable	Correlation (r)	Significance (p)	Direction
Parents' education	0.11	0.485	Nonsignificant

The findings show statistically significant correlations for four variables:

- Mathematical anxiety had a negative correlation with achievement.
- Mathematical memory had a positive correlation.
- Socioeconomic status was positively correlated.
- Number of siblings was negatively correlated.
- No significant differences were found by gender or parents' education.

Hypothesis 4:
There is a negative correlation between mathematical anxiety and mathematical memory ability.
Spearman's rank order correlation yielded $r = -0.39$, $p < 0.05$, confirming that higher anxiety is associated with weaker mathematical memory, while lower anxiety correlates with better memory performance.

4.4 Summary of Findings

1. Implementation of Kagan's cooperative learning strategies led to significant improvement in both mathematical achievement and communication skills.
2. The strategies helped narrow performance gaps and increased student participation and motivation.
3. Emotional and socioeconomic variables particularly math anxiety, memory, SES, and family size were found to influence achievement.
4. The strategies created a positive classroom climate that encouraged communication, collaboration, and self-efficacy.

These findings provide strong empirical support for the effectiveness of cooperative learning in mathematics education.

DISCUSSION AND CONCLUSIONS

5.1 Discussion

The present study aimed to investigate the impact of applying Kagan's cooperative learning strategies Numbered Heads Together and Quiz-Quiz-Trade on sixth grade students' mathematical achievement and mathematical communication skills in Arab elementary schools in northern Israel. The discussion below interprets the results in light of existing literature and theoretical frameworks.

Improvement in Mathematical Achievement

The results revealed a statistically significant increase in the experimental group's mathematics test scores after the implementation of Kagan's strategies.

The mean achievement rose from 66.5 to 82.5, representing a substantial improvement of 16 points. This finding aligns with previous research emphasizing that cooperative learning enhances academic achievement by fostering active participation, peer teaching, and shared responsibility (Slavin, 1995; Johnson & Johnson, 2009; Gillies, 2014).

Several mechanisms may explain this improvement:

1. Positive interdependence students realized that the group's success depended on each member's contribution, motivating engagement and effort.
2. Individual accountability because any student might be called to answer, everyone had to understand the material thoroughly.
3. Increased interaction and feedback continuous peer exchange improved comprehension and retention.
   In this sense, cooperative learning replaces traditional "teacher centered instruction" with an active environment that stimulates understanding through communication and collaboration.

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Enhancement of Mathematical Communication
The second major finding concerns the development of mathematical communication skills.

The average score increased from 1.81 to 3.10, demonstrating a marked improvement in all five areas: reading, writing, speaking, listening, and representation.

These results support the view that cooperative learning fosters mathematical literacy the ability to express, interpret, and connect mathematical ideas.
According to Sfard (2008), communication is not simply a means of expressing mathematical understanding but the process through which understanding itself is constructed.

In structures such as Quiz-Quiz-Trade, students explain, correct, and reinterpret mathematical ideas through interaction.

Similarly, Numbered Heads Together promotes mutual reasoning and shared explanations that strengthen comprehension.

The findings echo Klein (2007) and Raviv & Shamir (2007), who demonstrated that verbalizing thought processes deepens cognitive understanding and enhances mathematical reasoning. Speaking and listening thus become tools for cognitive development not peripheral skills.

Socio Demographic and Emotional Variables
The study also explored how background variables relate to achievement.

The results showed:

- Mathematical anxiety had a negative correlation with achievement ($r = –0.42$), confirming that anxiety interferes with concentration and working memory (Nasser, 2007; Boaler, 2008).
- Mathematical memory ability correlated positively ($r = 0.48$), reinforcing the role of cognitive readiness in academic success.
- Socioeconomic status (SES) had a positive correlation ($r = 0.36$), consistent with studies linking SES to educational opportunities and parental support (Sirin, 2005; OECD, 2019).
- Number of siblings correlated negatively ($r = –0.31$), supporting the Resource Dilution Theory (Blake, 1989; Downey, 2001).

No significant relationship was found between gender or parents' education and achievement, in line with Hyde et al. (2008) and Boaler (2016).

Together, these findings highlight that mathematics learning is influenced not only by cognitive and instructional factors but also by emotional and environmental conditions.

The combination of supportive peer interaction and cooperative pedagogy can mitigate some of these disparities by enhancing motivation, confidence, and engagement.

Reduction of Mathematical Anxiety
One of the noteworthy contributions of this research is the observed reduction in mathematical anxiety among students in the experimental group.

Cooperative learning created a classroom environment based on mutual support, shared responsibility, and constructive feedback.

This finding is consistent with Johnson & Johnson (2009) and Ryzin & Roseth (2023), who found that cooperative settings reduce stress and foster belonging.

ISSN: 2178-7727

Students reported feeling less fear of failure and more confidence when solving problems in small groups. By normalizing mistakes and valuing explanation over speed, Kagan's structures help transform mathematics into a collaborative, less threatening subject.

Development of self-Efficacy and Social Skills

The improvement in communication and participation suggests growth in students' self-efficacy their belief in their ability to succeed.

As Bandura's (1997) theory predicts, success experiences, peer modeling, and social persuasion enhance confidence and persistence.

Cooperative learning provided precisely these experiences: repeated success, recognition, and mutual encouragement.

Students also developed social and emotional competencies such as empathy, patience, and cooperation essential skills for both academic and personal development.

The positive social climate further reinforced motivation and engagement.

5.2 Conclusions

Based on the study's findings, several conclusions can be drawn:

1. Kagan's cooperative learning strategies significantly improve both mathematical achievement and communication skills.
   The structured, interactive nature of these methods enables deep understanding, increased engagement, and stronger retention of mathematical concepts.
2. Cooperative learning transforms classroom dynamics moving from passive learning to active, student centered collaboration.
   It encourages equal participation and mutual responsibility for learning.
3. The development of mathematical communication skills reading, writing, speaking, listening, and representation is an essential outcome of cooperative learning.
   These skills form the foundation of mathematical literacy and higher order thinking.
4. Cooperative learning reduces mathematical anxiety and strengthens self-confidence by providing a safe, supportive learning environment.
5. Socioeconomic and emotional factors influence achievement but can be moderated through inclusive and cooperative teaching strategies.
6. Teacher training in the design and facilitation of cooperative learning is crucial for successful implementation.

5.3 Practical Recommendations

For Teachers

- Incorporate cooperative learning strategies such as Numbered Heads Together and Quiz-Quiz-Trade into mathematics instruction.
- Encourage students to explain reasoning verbally, listen to peers, and construct shared understanding.
- Provide continuous formative feedback that values reasoning and collaboration over speed or rote correctness.

For School Administrators

- Support professional development programs focusing on cooperative pedagogy and classroom management within group learning.
- Promote a school culture that values teamwork, mutual respect, and communication as part of mathematical learning.

ISSN: 2178-7727

For Policy Makers

- Integrate cooperative learning frameworks into the national mathematics curriculum, particularly in schools serving under resourced communities.
- Encourage assessment methods that include communication and reasoning skills alongside procedural fluency.

For Future Research

- Conduct longitudinal studies to examine the long term impact of cooperative learning on mathematical understanding and student attitudes.
- Explore its applicability in other subject areas such as science and language.
- Investigate digital adaptations of cooperative learning for hybrid or online environments.

5.4 Limitations of the Study

Despite its significant contributions, this study has several limitations:

1. Sample size limited to 60 students in one school, which restricts generalizability.
2. Duration the intervention covered only six lessons; longer interventions might yield more robust conclusions.
3. Scope focused on one mathematical topic (percentages), not the entire curriculum.
4. Measurement tools relied mainly on self-reported questionnaires and achievement tests; qualitative data such as observations or interviews could provide richer insights.

These limitations point to the need for further studies with larger, more diverse samples and mixed method approaches.

5.5 Final Remarks

The findings of this research confirm that cooperative learning when implemented through structured, theory based strategies such as those of Kagan can profoundly enhance both academic and emotional dimensions of mathematics learning.

It encourages students to engage, communicate, and construct understanding collaboratively.

Mathematics, often perceived as a solitary and intimidating discipline, becomes through cooperation a shared intellectual journey one that develops not only knowledge but also empathy, confidence, and joy in learning. By embracing such pedagogies, educators can nurture a generation of learners who approach mathematics not with fear, but with curiosity and collaboration.

REFERENCES

1. AlDib, M. (2011). *The effect of cooperative learning on students' achievement in mathematics in primary schools.* Journal of Educational Research, 12(3), 45–58.
2. Bandura, A. (1997). *Selfefficacy: The exercise of control.* New York: Freeman.
3. Bedouin, M. (2003). *Developing mathematical communication among elementary school students through cooperative learning.* Haifa: University of Haifa. [Hebrew]
4. Berliner, D. (2006). *Educational research: The hardest science of all.* Educational Researcher, 35(8), 3–13.
5. Blake, J. (1989). *Family size and achievement.* Science, 245(4913), 32–38.
6. Boaler, J. (2008). *Promoting equity in mathematics classrooms through open communication and collaboration.* Educational Studies in Mathematics, 68(3), 283–302.
7. Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages, and innovative teaching.* San Francisco: JosseyBass.
8. Bruner, J. (1996). *The culture of education.* Cambridge, MA: Harvard University Press.
9. Ceka, A., & Murati, R. (2016). *The role of teachers in motivating students to learn.* Journal of Education and Practice, 7(4), 158–165.

10. Cobb, P., & Yackel, E. (1996). *Constructivist, emergent, and sociocultural perspectives in the context of developmental research.* Educational Psychologist, 31(3–4), 175–190.
11. Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). *Math–gender stereotypes in elementary school children.* Child Development, 82(3), 766–779.
12. Downey, D. (2001). *Number of siblings and intellectual development: The resource dilution explanation.* American Psychologist, 56(6–7), 497–504.
13. Eccles, J. S., Wigfield, A., & Schiefele, U. (2000). *Motivation to succeed.* In W. Damon (Ed.), *Handbook of Child Psychology* (pp. 1017–1095). New York: Wiley.
14. Fan, X., & Chen, M. (2001). *Parental involvement and students' academic achievement: A metaanalysis.* Educational Psychology Review, 13(1), 1–22.
15. Gillies, R. (2014). *Cooperative learning: Developments in research.* International Journal of Educational Psychology, 3(2), 125–140.
16. Gillies, R., & Boyle, M. (2010). *Teachers' reflections on cooperative learning: Issues of implementation.* Teaching and Teacher Education, 26(4), 933–940.
17. Hattie, J. (2009). *Visible learning: A synthesis of over 800 metaanalyses relating to achievement.* London: Routledge.
18. Hibi, W. (2017). Beliefs and attitudes about mathematics among students and their relationship to their achievement in mathematics. Journal of Harbin Institute of Technology, 49(11), 47-57. http://hebgydxxb.periodicales.com/index.php/JHIT/article/view/879
19. Hibi, W. (2018). The effect of origami's educational and geometrical interaction on sixth graders. Journal of Harbin Institute of Technology, 50(11), 33-40. http://hebgydxxb.periodicales.com/index.php/JHIT/article/view/735
20. Hibi, W. (2020). Polynomial coloring applications. *Yantu Gongcheng Xuebao/Chinese Journal of Geotechnical Engineering, 42*(7), 1-4.
21. Hibi, W. (2021a). General uses in intermediate value theorems. Multicultural Education, 7(8), 436-439. http://ijdri.com/me/wp-content/uploads/2021/08/48.pdf
22. Hibi, W. (2021b). Isometric between spaces $\ell\infty$, $\ell 1$. Advances in Mechanic, 9(3), 432-439. https://advancesinmechanics.com/pdf/137-242.pdf
23. Hibi, W. (2021c). On regular graph, that has two types of faces that having two consecutive numbers of edges. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(14), 1566-1571. https://turcomat.org/index.php/turkbilmat/article/view/10479
24. Hibi, W. (2021d). The Beckman-Quarles theorem for rational spaces. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(7), 1907-1912. https://turcomat.org/index.php/turkbilmat/article/view/3120
25. Hibi, W. (2021e). The Beckman-Quarles theorem for rational spaces, Mappings of Q^5 to Q^5 that preserve distance. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(7), 1913-1917.
26. Hibi, W. (2021f). The Beckman-Quarles theorem for rational spaces: Mapping of Q^d to Q^d that Preserve distance 1. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(7), 1938-1949.
27. Hibi, W. (2022a). Assembling Planer Graphs to Service the Coloring Number. *Review of International Geographical Education Online, 12*(1), 28-31.
28. Hibi, W. (2022b). Attitudes and perceptions of lecturers at Sakhnin College towards the integration of online teaching and innovative teaching methods and innovative teaching technologies, *Journal of Positive Psychology and Wellbeing, 6*(2), 2090-2105.
29. Hibi, W. (2022c). Definitions of ratio and proportionality terms and their relationship to cognitive and meta-cognitive orientation in the proportional thinking of preparatory level students. *Multicultural Education, Caddo Gap Press, 3145 Geary Boulevard, PMB 275, San Francisco, CA 94118 U.S.A, 8*(2),12-34.
30. Hibi, W. (2022d). Excerpts on mathematics education in the Arab community in Israel. Caddo Gap Press, 3145 Geary Boulevard, PMB 275, San Francisco, CA 94118, U.S.A ISBN: 874-745-05-5478-3 (eBook). Library Number: 2458796325.

ISSN: 2178-7727

31. Hibi, W. (2022e). The educational and geometric psychological impact of origami on sixth graders. Journal of Positive Psychology and Wellbeing, 6(1), 2031-2039. https://journalppw.com/index.php/jppw/article/view/2893
32. Hibi, W. (2022f). The Positive Impact of Combining Daily Math with First-Class Equation Learning for Middle School Students, Yantu Gongcheng Xuebao Chinese Journal of Geotechnical Engineering. Vol. 44 No. 6 (2022), 31-44.
33. Hibi, W. (2022g). Relationships between faces in regular, connected, and planar graphs. *Yantu Gongcheng Xuebao/Chinese Journal of Geotechnical Engineering*, *44*(1), 1-5. https://ytgcxb.periodicales.com/index.php/CJGE/article/view/70
34. Hibi, W. (2024a). A lesson in philosophy of high school geometry: Strange circle and discrete space. The International Journal of Science, Mathematics and Technology Learning, 31(2), 45-69. https://doi.org/10.18848/2327-7971/CGP/v31i02/45-69
35. Hibi, W. (2024b). Mathematical distance learning in the Israeli Arab middle schools during COVID: Teachers' point of view. International Journal of Learner Diversity and Identities, 31(1). https://scholarsarchives.com/arcijld/wp-content/uploads/2024-31-1-7-1.pdf
36. Hibi, W. (2024c). Using smart applications to develop mathematical concepts among fourth-grade students with arithmetic learning difficulties. The International Journal of Science, Mathematics and Technology Learning, 32(1), 1. https://doi.org/10.18848/2327-7971/CGP/v32i01/1-28
37. Hibi, W. (2024d). Using the (4MAT) model in teaching the triangles similarity unit for the ninth grade. Journal of Positive Psychology and Wellbeing, 8(2), 108-125. https://www.journalppw.com/index.php/jppw/article/view/18237
38. Hibi, W. (2024e). Written Calculation Ability and Numerical Insight in Grades 6 and 7 among the Arab Sector in Israel. Mathematics Teaching-Research Journal. https://mtrj.commons.gc.cuny.edu/volume-16-n-5/
39. Hibi, W. (2025a). Bridging Home and School: Rethinking Everyday Mathematics Through the Lens of Cultural Commodity. International Journal of Multicultural Education, 27(1),33-52. https://doi.org/10.5281/zenodo.15728013
40. Hibi, W. (2025b). Developing Mathematics Education by Integrating Graph Theory into college Curricula. *Multicultural Education*, *11*(1),64-75. DOI: 10.5281/zenodo.14639723
41. Hibi, W. (2025c). How AI Tools Influence the Skills of Young Developers. *International Journal of Multicultural Education*, *27*(1),33-52.
42. Hibi, W., & Khalifa, W. (2025d). Developing Numerical Understanding in Early Mathematics Subtraction. International *Journal of Multicultural Education*, *27*(1),14-32. https://doi.org/10.5281/zenodo.15728062
43. Hibi, W. (2025e). From Notes to Numbers: The Impact of Music Education on Mathematical Skills and Cognitive Development. *Acta Scientiae, revista Ensino de Ciênciase Matemática, 26*(1),*181-195.* https://www.periodicos.ulbra.org/index.php/acta/article/view/373
44. Hibi, W. (2025f). Institutional and Ideological Forces in Mathematics Discourse a Critical Perspective. *Acta Scientiae, revista Ensino de Ciências e Matemática*, *26*(1),*164-180.* https://www.periodicos.ulbra.org/index.php/acta/article/view/373
45. Hibi, W. (2025g). Proof, Attitudes, and Gender: A Study in Early Math Education. Multicultural Education, 11(4),50-66. DOI: 10.5281/zenodo.15263408
46. Hibi, W. (2025h). Teaching Parallelograms Using Geometer’s Sketchpad. International Journal of Stress Management, 32(1), 18-41. https://apa-ijsm.org/volume-32-issue-1/
47. Hyde, J. S., Fennema, E., & Lamon, S. (2008). *Gender differences in mathematics performance: A metaanalysis.* Psychological Bulletin, 136(2), 112–139.
48. Iddrisu, A., & Alhassan, F. (2025). *Socioeconomic disparities and academic achievement in developing countries.* International Journal of Social Research, 14(1), 55–70.
49. Johnson, D. W., & Johnson, R. T. (2009). *An educational psychology success story: Social interdependence theory and cooperative learning.* Educational Researcher, 38(5), 365–379.
50. Kagan, S. (1994). *Cooperative learning.* San Clemente, CA: Kagan Publishing.

ISSN: 2178-7727

51. Klein, J. (2007). *Mathematical communication as a tool for understanding.* Journal of Mathematics Education, 10(2), 45–61.
52. Kress, T. (2025). *Poverty, stress, and student performance: A socioeducational perspective.* Journal of Educational Policy, 19(4), 299–317.
53. Laal, M., & Ghodsi, S. (2012). *Benefits of collaborative learning.* Procedia – Social and Behavioral Sciences, 31, 486–490.
54. Marzano, R., Pickering, D., & Pollock, J. (2001). *Classroom instruction that works.* Alexandria, VA: ASCD.
55. Nasser, F. (2007). *Mathematics anxiety and achievement: The moderating role of gender and age.* Educational Studies in Mathematics, 64(3), 277–292.
56. OECD. (2019). *PISA 2018 results: What students know and can do.* Paris: OECD Publishing.
57. Raviv, D., & Shamir, H. (2007). *The influence of cooperative learning on the development of mathematical communication.* Journal of Education, 22(3), 45–66.
58. Roseth, C., Johnson, D., & Johnson, R. (2008). *Promoting early adolescents' achievement and peer relationships: The effects of cooperative, competitive, and individualistic goal structures.* Psychological Bulletin, 134(2), 223–246.
59. Ryzin, M., & Roseth, C. (2023). *Reducing anxiety through peer cooperation in mathematics education.* Educational Psychology, 43(5), 401–419.
60. Sfard, A. (2008). *Thinking as communicating: Human development, the growth of discourse, and mathematizing.* Cambridge: Cambridge University Press.
61. Sirin, S. (2005). *Socioeconomic status and academic achievement: A metaanalytic review of research.* Review of Educational Research, 75(3), 417–453.
62. Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice.* Boston: Allyn & Bacon.
63. Steelman, L., Powell, B., Werum, R., & Carter, S. (2002). *Reconsidering the effects of sibling configuration: Recent advances and challenges.* Annual Review of Sociology, 28, 243–269.
64. Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.
65. Wai, J., Cacchio, M., Putallaz, M., & Makel, M. C. (2010). *Sex differences in the right tail of cognitive abilities: A 30year examination.* Intelligence, 38(4), 412–423.
66. Zakaria, E., Chin, L. C., & Daud, M. Y. (2010). *The effects of cooperative learning on students' mathematics achievement and attitude toward mathematics.* Journal of Social Sciences, 6(2), 272–275.