INNOVATIVE RESEARCH JOURNAL VOL:3, ISSUE:2, 12-DECEMBER, 2023

https://doi.org/10.3126/irj.v3i2.61802

Overview of Cooperative Learning Strategies in Mathematics Teaching and Learning

Nara Hari Acharya
narahari.acharya@sac.tu.edu.np
Sanothimi Campus, Bhaktapur

Abstract:

This conference paper aims to provide an overview of the potential benefits and challenges associated with implementing cooperative learning strategies in mathematics education. By examining various cooperative learning models and their impact on students' learning outcomes, the paper highlights the importance of collaboration and group work in promoting deeper understanding, higher achievement, and improved attitudes toward mathematics. Traditional instructional methods often rely on individual work and teacher-centered approaches, which may limit students' engagement and development of mathematical reasoning abilities. Cooperative learning, however, emphasizes collaboration, active participation, and peer interaction, creating a supportive and interactive learning environment. This paper reviews the literature on cooperative learning in mathematics education, discusses its benefits, and provides practical recommendations for implementing cooperative learning strategies in mathematics classrooms.

Keywords: *cooperative, strategies, critical, facilitation, mathematics, group works*.

Received: 13 October, 2023 Revision Accepted: 10 December, 2023 Published: 12 December, 2023

Introduction

Cooperative learning in mathematics is an instructional approach that involves students working together in small groups to learn and solve mathematical problems collaboratively. This method emphasizes active participation, communication, and mutual support among students, fostering deeper conceptual understanding and improving mathematical achievement. Cooperative learning is grounded in the theory of social constructivism, which posits that learning occurs through active engagement, social interaction, and shared knowledge construction (Vygotsky, 1978). In the context of mathematics, cooperative learning provides opportunities for students to explain their thinking, discuss mathematical ideas, and learn from their peers (Cohen, 1994).

Cooperative learning strategies in mathematics have emerged as an effective approach to fostering student engagement, understanding, and problem-solving skills. These strategies promote collaboration and active participation among students, allowing them to learn from one another while working towards a common goal (Johnson, Johnson, & Holubec, 2013). By incorporating various cooperative learning techniques, teachers can create a supportive learning environment that nurtures critical thinking, communication, and individual responsibility (Slavin, 2014).

Cooperative learning strategies have become an essential aspect of modern education, promoting collaboration and interaction among students to enhance their academic performance and social skills. According to Johnson, Johnson, and Holubec (2013), cooperative learning is an instructional strategy that requires students to work together in small, heterogeneous groups to achieve a common goal, with each member contributing their unique skills and knowledge. This approach fosters positive interdependence, individual accountability, and equal participation, which ultimately leads to improved learning outcomes (Slavin, 2014). In the context of mathematics education, cooperative learning has been shown to increase student engagement, boost problem-solving skills, and deepen the understanding of mathematical concepts (Kagan & Kagan, 2009). By incorporating cooperative learning strategies into the classroom, educators can create a more inclusive, dynamic, and effective learning environment for students. One key aspect of cooperative learning in mathematics is positive interdependence. Students work together in groups, and their success is dependent on the success of their group mates (Johnson et al., 1991). This promotes a sense of collective responsibility and encourages students to support and help each other in solving mathematical problems.

Cooperative learning strategies, such as Think-Pair-Share, Numbered Heads Together, and Jigsaw, graffittee, one stay others stray, are commonly used in mathematics classrooms. In Think-Pair-Share, students individually think about a problem, then discuss their ideas with a partner before sharing them with the whole class (Slavin, 1996). Numbered Heads Together involves assigning numbers to group members, and when a number is called, the student with that number shares their group's solution or explanation (Kagan, 1994). Jigsaw involves dividing a complex task or concept into subtopics, with each group member becoming an expert on one subtopic and then teaching it to their groupmates (Aronson et al., 1978).

Numerous studies have highlighted the benefits of cooperative learning in mathematics. For example, a meta-analysis by Roseth et al. (2008) found that cooperative learning had a positive effect on mathematics achievement, with greater gains observed when students engaged in both individual and group accountability. Another meta-analysis by Lou et al. (1996) demonstrated that cooperative learning had a significant impact on students' attitudes toward mathematics.

Cooperative learning in mathematics also contributes to the development of important mathematical practices, such as problem-solving, reasoning, and communication. Through group discussions and interactions, students learn to justify their mathematical thinking, critique the reasoning of others, and explore multiple solution strategies (NCTM, 2000).

An empirical literature review on cooperative learning in mathematics synthesizes findings from multiple research studies to provide an overview of the effects of cooperative learning on students' performance and attitudes. Here are some key findings from various studies:

A meta-analysis by Slavin et al. (2009) found that cooperative learning methods consistently led to higher student achievement in mathematics when compared to traditional instruction. This improvement was observed across different grade levels, group sizes, and cooperative learning techniques. Johnson and Johnson (1994) reported that cooperative learning helped students develop better problem-solving skills in mathematics. Students who participated in cooperative learning groups were more likely to use multiple strategies and approaches when solving problems. A study by Li et al. (2010) found that students who participated in cooperative learning activities had more positive attitudes toward mathematics compared to those in traditional classrooms. These positive attitudes were associated with increased motivation and engagement in the subject.

Webb and Farivar (1994) found that students who participated in cooperative learning developed better interpersonal skills and became more responsible learners. The study found that students who engaged in high-quality task-related verbal interaction demonstrated greater mathematics achievement than those who did not. The results underscore the importance of communication and collaboration in the cooperative learning process. It is found that Cooperative learning fosters the development of social and communication skills, as students learn to work collaboratively, negotiate ideas, and support their peers.

Cooperative learning has been shown to reduce the achievement gap between high- and low-performing students, as well as between students from different racial and socioeconomic backgrounds (Slavin, 1995).

In summary, the empirical literature shows that cooperative learning in mathematics can lead to improved academic performance, enhanced problem-solving skills, better attitudes toward mathematics, increased social skills and teamwork, and a reduced achievement gap. These findings suggest that incorporating cooperative learning strategies into mathematics classrooms can have significant benefits for students' learning and development.

By incorporating these cooperative learning strategies into the mathematics classroom, teachers can enhance student engagement, understanding, and problem-solving skills.

The digest identifies five essential elements of cooperative learning: positive interdependence, individual accountability, face-to-face interaction, interpersonal skills, and group processing. It also offers practical tips for implementing these elements in mathematics instruction Stahl, R. J. (1994). Gillies & Ashman (2000) found that students with learning difficulties who participated in cooperative learning groups demonstrated significantly higher mathematics achievement and social skills development than those in traditional, teacher-directed instruction.

It is important to note that successful implementation of cooperative learning in mathematics requires careful planning, structuring of group tasks, and monitoring of group dynamics by the teacher. Adequate support and scaffolding must be provided to ensure all students actively participate and contribute to the group's learning (Slavin, 2015).

Common Cooperative Learning Strategies in Mathematics

We can use the different strategies along with the group and pair works in mathematics teaching and learning. Some of them are described below.

Jigsaw Method

The Jigsaw Method involves dividing a larger task into smaller, interdependent pieces. Each student becomes an expert on their piece and teaches their group members about it. This method promotes collaboration and helps students develop problem-solving skills (Aronson et al., 1978).

For example, 'teaching the operation of sets at elementary level'

- First, we can divide all students into groups of 4 students.
- Distribute the list with the union of sets, the intersection of sets, a difference of two sets, and the complement of a set.
- After that let them distribute one title each within groups.
- Let them form new groups with similar titles as expert groups. Here the groups of union, intersection, difference, and complement are four expert groups.
- Let the expert groups discuss their topic and prepare a common document on definition, notation, example, and Venn diagram of the respective title.
- Let them turn back to home groups and share the content that they learned in expert groups turn by turn.
- Compile the ideas from each member from the expert group to the home group and finally prepare a complete document of union, intersection, difference, and complement of sets with their notation, examples, and Venn- diagram.

Kagan Structures

Kagan Structures are designed to promote interaction and equal participation among students. Some examples of Kagan Structures used in mathematics classrooms include RallyCoach, where students take turns coaching each other through a problem, and RoundRobin, where students take turns sharing their solutions with their group (Kagan & Kagan, 2009).

One example of a Kagan structure that can be effectively employed in mathematics teaching and learning is the "Rally Coach" method. This cooperative learning strategy encourages students to work in pairs, promote active learning, and provide support to one another while solving mathematical problems.

Here's a step-by-step guide on how to implement the Rally Coach method in a mathematics classroom:

- Form pairs: Divide students into pairs, ensuring that they are seated next to each other. Try to create heterogeneous pairs, matching students with different abilities to promote peer learning.
- Assign roles: Within each pair, designate one student as the "coach" and the other as the "player." These roles will alternate throughout the activity.
- Present the problem: Introduce a mathematics problem or set of problems that students need to solve. Make sure the problems are appropriate for the student's skill levels and aligned with the learning objectives.

- The player solves the problem: The player starts working on the problem, thinking aloud and explaining their thought process as they go. This helps the coach understand the player's approach and identify any errors or misconceptions.
- A coach provides support: The coach actively listens and provides guidance, encouragement, and assistance as needed. The coach should avoid solving the problem for the player but should instead ask guiding questions and offer hints to help the player reach the correct solution.
- Praise and switch roles: Once the player has solved the problem, the coach should offer praise and positive feedback. Then, the students switch roles, with the former coach becoming the player and vice versa.
- Repeat the process: Continue the Rally Coach method with additional problems, allowing students to practice their problem-solving skills and engage in collaborative learning.
- Debrief and reflect: After completing the activity, lead a whole-class discussion to review the problems, address common misconceptions, and reflect on the cooperative learning experience. Encourage students to share their thoughts on the Rally Coach process and discuss the benefits and challenges of working in pairs.

By implementing the Rally Coach Kagan structure in mathematics teaching and learning, educators can promote active learning, enhance students' problem-solving skills, and foster a supportive and collaborative learning environment.

Problem-Based Learning (PBL)

PBL involves students working together to solve real-world problems, fostering a deeper understanding of mathematical concepts. This approach encourages collaboration, critical thinking, and communication skills (Hmelo-Silver, 2004).

A well-known example of problem-based learning (PBL) in mathematics comes from the MARS (Mathematics Assessment Resource Service) project, which has developed a series of PBL tasks for math education.

For example: "The Fencing Task":

Problem description: A farmer has 100 meters of fencing to use to create a rectangular enclosure for her sheep. The student's task is to determine the dimensions of the rectangle that will maximize the area enclosed by the fence.

Steps to implement the PBL activity:

- Introduce the problem: Present the problem to students, ensuring they understand the context and constraints of the task.
- Divide students into small groups: PBL is most effective when students collaborate in groups of 3-5 members.
- Encourage exploration and inquiry: Allow students to discuss and brainstorm different approaches to solving the problem. Encourage them to explore various dimensions and shapes for the enclosure, considering the relationship between area and perimeter.
- Facilitate learning: As students work on the problem, circulate around the room, asking guiding questions, providing feedback, and ensuring that each group stays on task.

- Require justification and reflection: As students arrive at their solutions, ask them to justify their reasoning and explain how they determined the optimal dimensions for the enclosure.
- Share solutions: Have each group present their solution to the class, discussing the steps they took, the challenges they encountered, and the strategies they used to solve the problem.
- Debrief and connect: After all groups have presented, lead a whole-class discussion about the problem-solving process, the various solutions, and the mathematical concepts involved. Connect the PBL task to the broader curriculum and reinforce the importance of mathematical reasoning and problem-solving skills.

Gallery Walk

A gallery walk is an interactive teaching strategy that encourages student engagement, collaboration, and critical thinking. In a mathematics classroom, a gallery walk can be used to explore different mathematical concepts, problem-solving techniques, or real-world applications. Here's an example of how a gallery walk can be implemented in a mathematics lesson on the topic of geometric transformations:

Preparation:

Create several posters or stations around the classroom, each featuring a different geometric transformation, such as translation, rotation, reflection, and dilation. Include a visual representation of the transformation, a brief description, and an example problem for students to solve.

Divide students into small groups:

Divide the class into small groups, with each group starting at a different station. Assign each group a unique identifier, such as a color or number, to help them track their progress.

Explore the stations:

Give students a set amount of time (e.g., 5-7 minutes) to explore the information at their station, discuss it with their group members, and collaboratively solve the example problem. Encourage students to take notes and ask questions during this time.

Rotate stations:

After the allotted time, instruct groups to rotate to the next station in a predetermined order. Repeat this process until all groups have visited each station.

Reflection and discussion:

Once all groups have completed the gallery walk, bring the class together for a reflection and discussion session. Ask students to share their observations, insights, and any patterns they noticed across the different geometric transformations. Facilitate a discussion on the applications of these transformations in real-world contexts, such as architecture, art, or engineering.

Assessment and feedback:

Collect students' notes and problem-solving work as a form of formative assessment. Provide feedback on their understanding of geometric transformations and their ability to apply these concepts to problem-solving tasks.

A gallery walk in mathematics teaching not only exposes students to various concepts and techniques but also promotes active learning, collaboration, and critical thinking. By engaging in this activity, students can develop a deeper understanding of mathematical concepts and improve their problem-solving skills (Sharan & Sharan, 1992).

Think-Pair-Share

In this strategy, students think about a problem individually and then pair up with a partner to discuss their ideas before sharing their solutions with the whole class. This approach encourages active participation and promotes a deeper understanding of mathematical concepts (Lyman, 1981). In this strategy, first, each student is requested to write their ideas individually, and after that let them share in a pair of left elbow partners. After that share the common idea of the pair in the whole class turn by turn.

In similar ways, graffiti, group invention, paper gallery, pyramid study, and one stay others stay are the different cooperative learning strategies to teach mathematics effectively.

Conclusion

Mathematics is a universal as well as the discipline-integrated subject. That is why each person and person should have a conceptual understanding of mathematics. Cooperative learning in mathematics is very useful not only for depth knowledge but also the conceptual as well as methodological insights (Kurniati et al., 2015). For the active and effective instructional approach to promote active engagement, collaboration, and conceptual understanding Cooperative learning plays a key role among students (Aronson, 2021). By working together in groups, students develop their mathematical thinking, problem-solving skills, and communication abilities. Cooperative learning enhances mathematical achievement and fosters a positive learning environment in the mathematics classroom not only for students but also the teachers, policymakers, and other stakeholders.

References

Aronson, E., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). The jigsaw classroom. Sage Publications.

Aronson, E. (2021). The jigsaw classroom: A personal odyssey into a systemic national problem. Pioneering perspectives in cooperative learning, 146-164.

Cohen, E. (1994). Restructuring the classroom: Conditions for productive small groups. Review of Educational Research, 64(1), 1-35.

DeVries, D. L., & Edwards, K. L. (1974). Cooperative games and sports: Joyful activities for everyone. Dubuque, IA: Wm C Brown.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235-266.

Johnson, D. W., & Johnson, R. T. (1994). Learning together and alone: Cooperative, competitive, and individualistic learning (4th ed.). Allyn and Bacon.

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (2013). Cooperation in the classroom (9th ed.). Interaction Book Company.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). Cooperative learning: Increasing college faculty instructional productivity. ASHE-ERIC Higher Education Report No. 4.

Kagan, S. (1994). Cooperative learning. San Juan Capistrano, CA: Resources for Teachers.

Kagan, S., & Kagan, M. (2009). Kagan Cooperative Learning. Kagan Publishing.

Kurniati, K., Kusumah, Y. S., Sabandar, J., & Herman, T. (2015). Mathematical critical thinking ability through contextual teaching and learning approach. Journal on Mathematics Education, 6(1), 53-62.

Li, T., & Lam, B. H. (2010). Building a new structure for school leadership. The American Educational Research Association.

Lou, Y., Abrami, P. C., Spence, J. C., Poulsen, C., Chambers, B., & d'Apollonia, S. (1996). Within-class grouping: A meta-analysis. Review of Educational Research, 66(4), 423-458.

Lyman, F. (1981). The responsive classroom discussion: The inclusion of all students. In A. Anderson (Ed.), Mainstreaming Digest (pp. 109-113, 51-56). University of Maryland College of Education.

National Council of Teachers of Mathematics (NCTM). (2000). Principles and standards for school mathematics. Reston, VA: NCTM.

Roseth, C. J., Johnson, D. W., & Johnson, R. T. (2008). Promoting early adolescents' achievement and peer relationships: The effects of cooperative, competitive, and individualistic goal structures. Psychological Bulletin, 134(2), 223-246.

Sharan, S., & Sharan, Y. (1992). Expanding cooperative learning through group investigation. New York: Teachers College Press.

Slavin, R. E. (1994a). Cooperative learning and student achievement. In J. Hattie & E. Anderson (Eds.), International encyclopedia of education (Vol. 1, pp. 1625-1630). Oxford: Pergamon Press.

Slavin, R. E. (1995). Cooperative learning: Theory, research, and practice (2nd ed.). Allyn and Bacon.

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. Contemporary Educational Psychology, 21(1), 43-69.

Slavin, R. E. (2014). Cooperative learning and academic achievement: Why does group work work? *Anales de Psicología/Annals of Psychology*, 30(3), 785-791. https://doi.org/10.6018/analesps.30.3.201201

Slavin, R. E. (2015). Cooperative learning in elementary schools. Education Canada, 55(4), 5-8.

Slavin, R. E., Lake, C., & Groff, C. (2009). Effective programs in middle and high school mathematics: A best-evidence synthesis. Review of Educational Research, 79(2), 839-911.

Slavin, R.E. (1995a). Cooperative Learning: Theory, Research and Practice (2nd ed.). Boston: Allyn and Bacon

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Webb, N. M., & Farivar, S. (1994). Promoting helping behavior in cooperative small groups in middle school mathematics. American Educational Research Journal, 31(2), 369-395.

Gillies, R. M., & Ashman, A. F. (2000). The effects of cooperative learning on students with learning difficulties in the lower elementary school. The Journal of Special Education, 34(1), 19-27.

Stahl, R. J. (1994). The essential elements of cooperative learning in the classroom. ERIC Digest.

http://map.mathshell.org/materials/index.php