Jurnal Pendidikan Matematika
UNIVERSITAS ISLAM MALANG

ARTICLE INFORMATION

The effect of collaborative learning on students' mathematical communication and problem-solving skills in polyhedra

Emilia, Fadrik Adi Fahrudin, Baiq Rofina Arvy
Corresponding author: 210103064.mhs@uinmataram.ac.id

How to cite (APA Style):
Emilia, Fahrudin, F. A., & Arvy, B. R. (2026). The effect of collaborative learning on students' mathematical communication and problem-solving skills in polyhedra. *Jurnal Pendidikan Matematika (JPM)*, *12*(1), 13-23. https://doi.org/10.33474/jpm.v12i1.24909

DOI	https://doi.org/10.33474/jpm.v12i1.24909
Contributions	**Emilia**: CCP, MTD, INV, DAC, ANL, WOD, WRE. **Fadrik Adi Fahrudin**: CCP, MTD, SPV, VLD, ANL, WRE. **Baiq Rofina Arvy**: INV, DAC, ANL, VLD, WRE.
Funding	This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
Conflict of Interest	The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.
Copyright ©	2026 Emilia, Fadrik Adi Fahrudin, and Baiq Rofina Arvy (the authors).
Declaration of AI Use	The authors declare that no generative artificial intelligence (AI) tools or AI-assisted technologies were used in the preparation, analysis, interpretation, or writing of this manuscript. All aspects of the research and manuscript preparation were conducted by the authors.

*** CRediT roles:** CCP: Conceptualization; MTD: Methodology; INV: Investigation; DAC: Data Curation; ANL: Formal Analysis; WOD: Writing - Original Draft; WRE: Writing - Review & Editing; SPV: Supervision; VLD: Validation.

JURNAL PENDIDIKAN MATEMATIKA (JPM)
Vol. 12, No. 1, 2026, pp 13–23 e-ISSN: 2656–4564
https://doi.org/10.33474/jpm.v12i1.24909
online at: https://riset.unisma.ac.id/index.php/jpm/article/view/24909/

THE EFFECT OF COLLABORATIVE LEARNING ON STUDENTS' MATHEMATICAL COMMUNICATION AND PROBLEM-SOLVING SKILLS IN POLYHEDRA

Emilia*, Fadrik Adi Fahrudin, Baiq Rofina Arvy
Universitas Islam Negeri Mataram, Indonesia
Email: *210103064.mhs@uinmataram.ac.id,*

ABSTRACT

This study aims to determine the effect of the Collaborative Learning model on students' mathematical communication skills and mathematical problem-solving skills in the topic of polyhedra (three-dimensional shapes with flat surfaces). This research employed a quantitative approach with a quasi-experimental method using a nonequivalent control group pretest–posttest design. The population of the study consisted of all eighth-grade students of MTs Manba'ul Ulum (Islamic Junior High School) Dasan Ketujur, West Lombok. The sample comprised two classes selected through cluster random sampling, namely one experimental class and one control class, each consisting of 30 students. The research instrument was an essay test used to measure students' mathematical communication skills and mathematical problem-solving skills. The data were analyzed using descriptive and inferential statistics, including the normality test, homogeneity test, independent samples t-test, and MANOVA test with the assistance of SPSS software. The results of the study indicate that students' mathematical communication skills and mathematical problem-solving skills in the experimental class improved more significantly than those in the control class. The results of the independent samples t-test revealed a significant difference between the experimental and control classes. Furthermore, the MANOVA test results showed that the Collaborative Learning model simultaneously had a significant effect on improving students' mathematical communication skills and mathematical problem-solving skills in the topic of polyhedra. The novelty of this study lies in examining the effectiveness of the Collaborative Learning model in improving two mathematical abilities simultaneously, namely mathematical communication skills and mathematical problem-solving skills on the topic of polyhedra (three-dimensional shapes with flat surfaces) using a multivariate analysis approach (MANOVA).

Keywords: Collaborative Learning, Mathematical Communication, Problem-Solving, Polyhedra, Mathematics Learning.

*** Corresponding Author Email:** 210103064.mhs@uinmataram.ac.id

Submission	Revised	Accepted	Published
December 10, 2025	January 9, 2026	January 18, 2026	February 6, 2026

How to cite (in APA style):
Emilia, Fahrudin, F. A., & Arvy, B. R. (2026). The effect of collaborative learning on students' mathematical communication and problem-solving skills in polyhedra. *Jurnal Pendidikan Matematika (JPM)*, *12*(1), 13–23. https://doi.org/10.33474/jpm.v12i1.24909

INTRODUCTION

Mathematics learning plays an important role in developing students' logical, systematic, critical, and analytical thinking skills. It is not only oriented toward mastering concepts and procedures but also emphasizes mathematical communication and mathematical problem-solving skills as essential competencies in the learning process (NCTM, 2000). The process of mathematics learning to date still tends to be theoretical and mechanistic, and has not adequately connected the learning material with students' prior knowledge or their real-life experiences in everyday contexts (Fahrudin and Wardhani, 2025). The essence of learning is not merely the delivery of a series of materials by the teacher; rather, it emphasizes the presentation of concepts that can develop students' thinking processes, possess meaningful value, and be applicable to their daily lives (Gleason et al., 2011; Kim & Park, 2024). To support the mathematics learning process, effective instructional materials are needed to help enhance students' understanding more optimally (Lestari and Aisyah, 2018; Pratiwi, 2019).

Each student has different approaches and stages in solving mathematical problems, which are influenced by their individual characteristics and abilities (Fahrudin et al., 2024). The use of interactive and contextual learning methods can improve students' mathematical communication skills (Soleha & Ihsanudin, 2024). This ability is necessary for students to be able to express ideas, explain their thinking processes, and apply mathematical concepts in various problem contexts. Meanwhile, problem-solving is an inseparable component of mathematics education and learning. Furthermore, problem-solving is categorized as a strategic competence, as reflected in the phases in which students understand the problem, select appropriate approaches and strategies, and construct and solve models to resolve the problem (Shinta Mariam et al., 2019).

The results of the international study conducted by PISA (Programme for International Student Assessment) in the field of mathematics, which measures students' mathematical communication skills, indicate that Indonesia consistently ranks among the lowest-performing countries. This condition is influenced by students' low interest in learning, which is largely associated with socio-economic factors. Therefore, it can be understood that mathematical communication skills in Indonesia remain relatively low compared to those in other countries (Dewi and Yeyen, 2022). Mathematical communication skills refer to students' ability to convey mathematical ideas and understanding, both orally and in writing, through symbols, diagrams, tables, or other forms of mathematical representations and discourse through which mathematical meaning is communicated and negotiated (Planas & Pimm, 2024).

In addition to mathematical communication, problem-solving is also the core of the learning process (Aisyah, 2018). Mathematical problem-solving skills are essential abilities that students must possess, as they serve as a key support in achieving mathematical competencies (Guntur, 2018). Meanwhile, mathematical problem-solving skills are related to students' ability to understand a problem, plan appropriate solution strategies, carry out the solution process, and evaluate the results obtained (Polya, 1973; Madzkiyah and Arifin, 2024; Santos-Trigo, 2024). However, in reality, students' mathematical communication and mathematical problem-solving skills are still relatively low. This indicates that the mathematics learning process has not fully engaged students actively in constructing and communicating knowledge.

Various studies indicate that students still experience difficulties in understanding and communicating concepts related to polyhedra (three-dimensional shapes with flat surfaces). A study conducted by (Safitri et al., 2022) showed that students' mathematical communication skills in the topic of polyhedra are still relatively low, causing students to have difficulties in explaining mathematical ideas and solving problems related to these concepts. Moreover, a study conducted by (Aulia Hanifah, 2023) showed that students' mathematical communication skills in the topic of polyhedra are still relatively low. Many students experience difficulties in expressing mathematical ideas and explaining the problem-solving process systematically.

Efforts to address these problems require the implementation of a learning model that fosters active interaction among students. One relevant model is Collaborative Learning. This learning model emphasizes students' collaboration in small groups to achieve learning objectives through discussion and joint problem-solving (Johnson and Johnson, 2014). Through collaborative learning, students are trained to express their opinions, listen to others' perspectives, and construct understanding collectively, thereby enabling their mathematical communication and problem-solving skills to develop more effectively.

Several previous studies have examined the effectiveness of collaborative learning in improving mathematical communication or problem-solving skills. However, most studies only focus on one aspect of mathematical ability and are rarely conducted on the topic of polyhedra at the junior secondary level. In addition, previous studies rarely analyze both abilities simultaneously using multivariate statistical analysis. Therefore, this study aims to examine the effect of collaborative learning on both mathematical communication and problem-solving skills simultaneously. İni untuk menunjukkan novelty. A study conducted by Febriliati, Mira Marlina, and Vidya Ayuningtyas entitled *"The Implementation of the Collaborative Learning Model to Improve Students' Mathematical Literacy and Learning Activities in Grade VII of Junior High School"* showed that the application of the Collaborative Learning model can improve students' mathematical literacy and learning activities in Grade VII of junior high school. There is a difference in mathematical literacy ability between students who use the Collaborative Learning model and those who use the conventional learning model. The data show that the posttest scores of the experimental class are better than those of the control class, with a significance value for the experimental class posttest of 0.079, indicating that the data are homogeneous (Febriliati et al., 2024). However, the study has limitations as it only focuses on students' mathematical literacy and learning activities, without examining other important mathematical abilities such as communication and problem-solving skills.

Based on the aforementioned description, this study aims to analyze the effect of the Collaborative Learning model on students' mathematical communication and mathematical problem-solving skills in the topic of polyhedra. The findings of this study are expected to contribute to the development of mathematics instruction and serve as a reference for teachers in implementing effective and meaningful learning models.

METHOD

This study employed a quantitative approach using a quasi-experimental method. The research design applied was the pretest–posttest control group design, which involves two groups: an experimental group and a control group. Both groups were given a pretest before the treatment and a posttest after the treatment to determine differences in students' mathematical communication and problem-solving skills before and after the instructional intervention (Sugiyono, 2019). The experimental group received instruction using the Collaborative Learning model, while the control group was taught using the conventional learning model commonly applied by the teacher. This design was selected because it provides a more accurate representation of the effect of the treatment on the variables under investigation.

The population of this study consisted of all eighth-grade students of MTs Manba'ul Ulum in the 2025 academic year. This population was selected because the students had studied or were currently studying the topic of polyhedra in accordance with the applicable curriculum. The sampling procedure was conducted by collecting preliminary data from the entire population, namely pre-research data of eighth-grade students at MTs Manba'ul Ulum, Dasan Ketujur. Based on this data, two classes were selected, with one class assigned as the experimental class and one class as the control class, each consisting of 30 students.

The variables in this study consisted of independent and dependent variables. The independent variable was the Collaborative Learning model, while the dependent variables comprised two variables: students' mathematical communication skills and mathematical problem-solving skills in the topic of polyhedra.

The research instruments used in this study were a mathematical communication skills test and a mathematical problem-solving skills test. The tests were constructed in the form of essay questions aligned with the indicators of each respective skill. The instruments were developed based on a test blueprint referring to the basic competencies and learning objectives of the polyhedra topic.

The data collection techniques used in this study included tests, observation, and documentation. The test consisted of a series of questions or exercises used to measure the skills, knowledge, intelligence, abilities, or aptitudes possessed by individuals or groups. Observation was conducted to monitor the implementation of the learning process in the classroom. Documentation served as supporting data for the test and observation results, including records, teaching modules, photographs of activities, and recordings.

Meanwhile, the data analysis techniques used in this study involved both descriptive and inferential statistical analyses. Descriptive analysis was employed to describe the pretest and posttest data, including the mean, maximum score, minimum score, and standard deviation. Inferential analysis was used to test the research hypotheses. Prior to hypothesis testing, prerequisite tests were conducted, including tests of normality and homogeneity. Subsequently, hypothesis testing was carried out using the t-test or MANOVA, adjusted to the research objectives and data characteristics, in order to determine the effect of the Collaborative Learning model on students' mathematical communication and mathematical problem-solving skills.

RESULT

Students' initial abilities were analyzed based on the results of the pretest and posttest on mathematical communication and mathematical problem-solving skills in both the experimental and control classes. This analysis was conducted to ensure that the two classes had relatively comparable initial abilities before the instructional treatment was administered.

Table 1. Descriptive Statistics of Mathematical Communication Skills

Class	N	Minimum	Maksimum	Mean	Std. Deviation
Pretest Eksperimen	30	14	40	27.50	6.962
Postest Eksperimen	30	25	79	58.17	10.790
Pretest Kontrol	30	7	42	28.07	7.153
Postest Kontrol	30	15	50	29.77	9.153

In the experimental class, which implemented the Collaborative Learning model, 30 students participated in both the pretest and posttest. The mean pretest score was 27.50, with a minimum score of 14 and a maximum score of 40. The standard deviation of the pretest was 6.962, indicating a considerable variation in students' scores. After the implementation of the Collaborative Learning model, the mean posttest score increased significantly to 58.17. The minimum and maximum scores were 25 and 79, respectively, with the standard deviation increasing to 10.790. This indicates that although there was a significant improvement in mathematical communication skills, the variation in scores among students also increased. In the control class, which applied the conventional teaching method, 30 students also took part in the pretest and posttest. The mean pretest score was 28.07, with a minimum score of 7 and a maximum score of 42. The standard deviation of the pretest was 7.153. In the posttest, the mean score increased to 29.77. The minimum and maximum scores were 15 and 50, respectively, with the standard deviation rising to 9.153. These results indicate that there was no significant improvement in mathematical understanding in the control class without the implementation of the Collaborative Learning model, and students' mathematical communication skills tended not to develop optimally.

Table 2. Descriptive Statistics of Mathematical Problem-Solving Skills

Class	N	Minimum	Maksimum	Mean	Std. Deviation
Pretest Eksperimen	30	16	40	37.83	7.273
Postest Eksperimen	30	35	75	55.07	10.957
Pretest Kontrol	30	15	50	27.93	7.597
Postest Kontrol	30	25	55	38.47	8.500

In the experimental class, which implemented the Collaborative Learning model, 30 students participated in both the pretest and posttest. The mean pretest score was 37.83, with a minimum score of 16 and a maximum score of 40. The standard deviation of the pretest was 7.273, indicating a considerable variation in students' scores. After the implementation of the Collaborative Learning model, the mean posttest score increased significantly to 55.07. The minimum and maximum scores were 37 and 75, respectively, with the standard deviation rising to 10.957. This indicates that although there was a significant improvement in mathematical problem-solving skills, the variation in scores among students also increased. In the control class, which applied the conventional teaching method, 30 students also participated in the pretest and posttest. The mean pretest score was 27.93, with a minimum score of 15 and a maximum score of 50. The standard deviation of the pretest was 7.597. In the posttest, the mean score increased to 38.47. The minimum and maximum scores were 25 and 55, respectively, with the standard deviation increasing to 8.500. These results indicate that there was no significant improvement in mathematical understanding in the control class without the implementation of the Collaborative Learning model, and students' mathematical problem-solving skills tended not to develop optimally.

Assumption Tests for Analysis:

Before conducting hypothesis testing, the data were first subjected to prerequisite tests, including tests of normality and homogeneity.

Table 3. Results of the Normality Test for Mathematical Communication Skills

Variable	Class	Shapiro Wilk			Conclusion
		Statistic	df'	Sig	
Eksperimen	Pretest Eksperimen	.956	30	408	Normal Distribution
	Postest Eksperimen	.956	30	246	Normal Distribution
Kontrol	Pretest Kontrol	.956	30	243	Normal Distribution
	Postets Kontrol	.948	30	154	Normal Distribution

Based on Table 3, the results of the normality test for the pretest and posttest data indicate that the significance values for the pretest were 0.408 and 0.243, while for the posttest they were 0.246 and 0.154. Since all significance values are greater than 0.05, the null hypothesis (H_0) is accepted. Therefore, it can be concluded that the data are normally distributed.

Table 4. Results of the Normality Test for Mathematical Problem-Solving Skills

Variable	Class	Shapiro Wilk			Conclusion
		Statistic	df'	Sig	
Eksperimen	Pretest Experiment	.952	30	194	Normal Distribution

	Postest Experiment	.947	30	554	Normal Distribution
Control	Pretest Control	.962	30	348	Normal Distribution
	Postets Control	.948	30	139	Normal Distribution

Based on Table 4, the results of the normality test for the pretest and posttest data indicate that the significance values for the pretest were 0.194 and 0.384, while for the posttest they were 0.554 and 0.139. Since all significance values are greater than 0.05, the null hypothesis (H_0) is accepted. Therefore, it can be concluded that the data are normally distributed.

Table 5. Results of the Homogeneity Test for Mathematical Communication Skills

		Levene Statistic	df1	df2	sig
Score	Based on mean	0.443	1	58	0.580
	Based on median	0.471	1	58	0.495
	Based on median and with adjusted df	0.471	1	56.510	0.495
	Based on trimmed mean	0.459	1	58	0.501

Based on the results of the homogeneity test in Table 5, the significance value obtained was 0.508. Since 0.508 is greater than 0.05, it can be concluded that the two data sets have equal variances, or in other words, are homogeneous.

Table 6. Results of the Homogeneity Test for Mathematical Problem-Solving Skills

		Levene Statistic	df1	df2	sig
Score	Based on mean	2.124	1	58	0.150
	Based on median	2.354	1	58	0.130
	Based on median and with adjusted df	2.354	1	57.094	0.131
	Based on trimmed mean	2.156	1	58	0.147

Based on the results of the homogeneity test in Table 6, the significance value obtained was 0.150. Since 0.150 is greater than 0.05, it can be concluded that the two data sets have equal variances, or in other words, are homogeneous.

Assumption Tests for Analysis:

The multivariate normality test was conducted using the Mahalanobis distance values. Based on the calculation results, all Mahalanobis distance values were smaller than the chi-square table value at a significance level of 0.001 with the corresponding degrees of freedom, which was 13.82.

Table 7. Results of the Homogeneity Test of the Variance–Covariance Matrix (Box's M Test)

Box's M	2.573
F	0.826
df1	3
df2	605520.000
Sig.	0.480

Based on the results of the homogeneity test of the variance–covariance matrix (Box's M test) in Table 7, the significance value of 0.480 is greater than 0.05. Therefore, it can be concluded that the variance–covariance matrices among the groups are homogeneous.

Hypothesis Testing:

Table 8. Results of the Independent Samples t-Test for Mathematical Communication Skills

		t	df	Sig. (2-tailed)
Score	Equal variances assumed	-10.994	58	0.001
	Equal variances not assumed	-10.994	56.497	0.001

As shown in Table 8, the independent samples t-test was conducted to compare the improvement in scores between the experimental group, which received the Collaborative Learning model, and the control group, which was taught using conventional methods. The results indicate a statistically significant difference in score improvement between the two groups. Specifically, Levene's test for equality of variances yielded a significance value of 0.014, indicating that the assumption of equal variances was not met. Nevertheless, the t-test results ($t = -10.994$, $df = 58$, $p < 0.001$) demonstrate that the mean improvement in mathematical understanding in the experimental group was significantly higher than that of the control group. The negative t-value indicates that the experimental group achieved greater gains in mathematical understanding compared to the control group. The very small p-value ($p < 0.001$) confirms that this difference is statistically significant, further supporting the hypothesis that the Collaborative Learning model is more effective in enhancing students' mathematical communication skills than the conventional instructional approach.

Table 9. Results of the Independent Samples t-Test for Mathematical Problem-Solving Skills

		t	df	Sig. (2-tailed)
Score	Equal variances assumed	-6.556	58	0.001
	Equal variances not assumed	-6.556	54.625	0.001

As shown in Table 9, the independent samples t-test was conducted to compare the improvement in scores between the experimental group, which received the Collaborative Learning model, and the control group, which was taught using conventional methods. The results indicate a statistically significant difference in score improvement between the two groups. Specifically, Levene's test for equality of variances yielded a significance value of 0.014, indicating that the assumption of equal variances was not met. Nevertheless, the t-test results ($t = -6.556$, $df = 58$, $p < 0.001$) show that the mean improvement in mathematical understanding in the experimental group was significantly higher than in the control group. The negative t-value indicates that the experimental group achieved greater gains in mathematical understanding compared to the control group. The very small p-value ($p < 0.001$) confirms that this difference is statistically significant, further supporting the hypothesis that the Collaborative Learning model is more effective in enhancing students' mathematical problem-solving skills than the conventional instructional approach.

Table 10. Results of the Multivariate Analysis of Variance (MANOVA)

Effect		Value	F	Hypothesis df	Error df	Sig.
İntercept	Pillai's trace	0.974	1055.999^b	2.000	57.000	<.001
	Wilks' lambda	0.026	1055.999^b	2.000	57.000	<.001
	Hotelling's trace	37.053	1055.999^b	2.000	57.000	<.001
	Roy's largest root	37.053	1055.999^b	2.000	57.000	<.001

Class	Pillai's trace	0.711	70.286[b]	2.000	57.000	<.001
	Wilks' lambda	0.289	70.286[b]	2.000	57.000	<.001
	Hotelling's trace	2.446	70.286[b]	2.000	57.000	<.001
	Roy's largest root	2.446	70.286[b]	2.000	57.000	<.001

Based on Table 10, the results show the multivariate significance test. The analysis can be seen in the second row under the "Class" section, where Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root all have significance values of 0.001, which is less than 0.05. This indicates that the Collaborative Learning model has a significant effect on students' mathematical communication and problem-solving skills.

DISCUSSION

The Effect of Collaborative Learning on Mathematical Communication Skills

The results of the study indicate that students who participated in learning using the Collaborative Learning model demonstrated better mathematical communication skills compared to those who received conventional instruction. These findings suggest that learning approaches that emphasize interaction and cooperation among students can create a learning environment that encourages students to actively express their mathematical ideas and thinking.

Mathematical communication skills encompass students' ability to express ideas orally and in writing, use mathematical symbols and representations accurately, and explain solution procedures logically. In Collaborative Learning, students have the opportunity to engage in discussions, ask questions, and provide explanations to their group members, thereby facilitating an intensive and continuous process of mathematical communication.

These finding is in line with (Fitriyanti et al., 2021), which indicates that collaborative learning can enhance students' mathematical communication skills because group interactions help students become accustomed to expressing ideas, constructing arguments, and responding to their peers' thoughts actively and reflectively.. Furthermore, collaborative learning also promotes active student engagement in the learning process, as emphasized by Gillies (2023), who noted that interaction in small groups significantly contributes to improving the quality of communication and student participation in learning.

Thus, the implementation of Collaborative Learning plays an important role in developing students' mathematical communication skills, particularly in mathematics learning that requires clarity of reasoning and the systematic expression of ideas.

The Effect of Collaborative Learning on Mathematical Problem-Solving Skills

In addition to its effect on mathematical communication skills, the results of the study indicate that the Collaborative Learning model also has a positive impact on students' mathematical problem-solving skills. Students who learned using this model demonstrated greater improvement in problem-solving abilities compared to those who were taught using conventional approaches.

Mathematical problem-solving skills involve several key stages, namely understanding the problem, designing a solution strategy, implementing the strategy, and evaluating the results obtained. Collaborative Learning encourages students to work together in analyzing problems and determining solution strategies, so that students not only rely on individual thinking but also learn from the perspectives of their group members.

These finding aligns with recent research, which indicates that the implementation of Collaborative Learning can significantly improve students' mathematical problem-solving skills, as group interactions help students become accustomed to planning strategies, expressing ideas, and actively responding to their peers' thoughts (Andrayani et al., 2025). Another study by Nurhayati et al. (2022) also demonstrated that interaction in small groups can significantly improve students' critical thinking and problem-solving abilities. Thus, Collaborative Learning makes a tangible contribution by training students to think systematically and strategically in solving mathematical problems.

The Effect of Collaborative Learning on Mathematical Communication and Problem-Solving Skills

The results of the study indicate that the implementation of the Collaborative Learning model has a simultaneous effect on students' mathematical communication and problem-solving skills. These findings suggest that collaborative learning not only impacts a single aspect of mathematical ability but also has the capacity to develop multiple cognitive skills in an integrated manner through group interaction and cooperation.

Mathematical communication skills and mathematical problem-solving skills are two interrelated abilities. Recent research on collaborative mathematical problem solving has emphasized that students' social interaction and mathematical communication are integral to the construction and refinement of problem-solving strategies (Cao, 2024). Students who can effectively communicate mathematical ideas tend to better understand problems, formulate solution strategies, and explain the solutions they obtain. In Collaborative Learning, students are encouraged to express their ideas, respond to their peers' opinions, and agree on solution strategies collectively, allowing mathematical communication and problem-solving processes to develop simultaneously.

Collaborative learning creates a learning environment that enables students to exchange ideas and problem-solving strategies. Group discussions help students view problems from multiple perspectives, correct misunderstandings, and refine the strategies they use. This process not only trains students to express their ideas orally and in writing but also habituates them to think systematically and logically when solving mathematical problems.

Moreover, collaboration within groups encourages students to be more active and responsible for the learning process. Students focus not only on the final outcome but also on the thinking process they undergo together. When students explain solution steps to their group members, they indirectly reinforce their conceptual understanding, enhance their mathematical communication skills, and simultaneously deepen their mathematical problem-solving abilities.

These findings are in line with the study conducted by (Tambunan, 2021), which concluded that the cooperative learning model can improve students' mathematical problem-solving skills and mathematical communication skills in mathematics learning.

CONCLUSION AND SUGGESTIONS

Based on the results of the study, the implementation of the Collaborative Learning model has a positive impact on students' mathematical communication and problem-solving skills in the topic of polyhedra. Cognitively, collaborative learning helps students understand concepts and develop problem-solving strategies through discussion and idea exchange. Affectively, this model promotes students' activeness, self-confidence, and willingness to express opinions and explain their mathematical thinking processes. These findings indicate that Collaborative Learning is an effective alternative instructional approach that supports active and meaningful learning.

This study has limitations as it was conducted only on the topic of polyhedra and involved research subjects within a limited scope. Therefore, future research is recommended to implement the Collaborative Learning model in other mathematics topics, at different educational levels, or by including additional variables such as learning motivation, attitudes toward mathematics, or academic achievement, in order to obtain a more comprehensive understanding of the effectiveness of collaborative learning.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to all parties who have provided support and contributions to the implementation of this study. Special thanks are extended to the supervising lecturers for their guidance, advice, and input throughout the research process and the preparation of this article. The author also wishes to thank the school authorities, teachers, and students who were willing to participate as research subjects and assisted in ensuring the smooth conduct of the study. Additionally, appreciation is conveyed to everyone who offered moral and technical support, enabling this research to be carried out successfully.

REFERENCES

Aisyah, N. (2018). Problem-solving learning in mathematics. *Jurnal Pendidikan Matematika*, 12(2), 45–53. https://journal.univpancasila.ac.id/index.php/didacticalmathematics

Andrayani, A., Fitri, H., & Imamuddin, M. (2025). The effect of the collaborative learning model on the mathematical problem-solving ability of Grade VIII students at SMPN 1 Sasak Ranah Pesisir in the 2023/2024 academic year. *TOFEDU: The Future of Education Journal, 4*(4), 979–986. https://doi.org/10.61445/tofedu.v4i4.510

Cao, Y. (Ed.). (2024). *Students' collaborative problem solving in mathematics classrooms: An empirical study*. Springer. https://doi.org/10.1007/978-981-99-7386-6

Dewi, R. S., & Yeyen, R. (2022). Analysis of students' mathematical communication skills based on PISA results. *Jurnal Pendidikan Matematika dan Sains*, 10(1), 15–25. https://journal.uny.ac.id/index.php/jpms

Fahrudin, F. A., Sa'dijah, C., Hidayanto, E., & Susanto, H. (2024). Student's reversible thinking processes: An analysis based on adversity quotient type climbers. *Qualitative Research in Education, 13*(1), 19–42. https://doi.org/10.17583/qre.11964

Fahrudin, F. A., & Wardhani, I. S. (2025). Integrative-interconnective approach in sets: A teaching material development for enhancing students' conceptual understanding. *Journal for Lesson and Learning Studies, 8*(1), 21–35. https://doi.org/10.23887/jlls.v8i1.89052

Fitriyanti, F., Laras, I. S., Khasanah, K., Anita, I. D., & Rahmawati, F. (2021). Implementasi metode collaborative learning dalam pembelajaran statistika untuk meningkatkan keterampilan 4C (*critical and problem solving skills, collaboration skills, communication skills, and creativity and innovation skills*) pada siswa kelas XI [Implementation of collaborative learning in statistics learning to improve students' 4C skills]. *Edunesia: Jurnal Ilmiah Pendidikan, 2*(1), 249–259. https://doi.org/10.51276/edu.v2i1.115

Gillies, R. M. (2023). Using cooperative learning to enhance students' learning and engagement during inquiry-based instruction. *Education Sciences, 13*(12), Article 1242. https://doi.org/10.3390/educsci13121242

Johnson, D. W., & Johnson, R. T. (2014). Cooperative learning in 21st century. *Anales de Psicología, 30*(3), 841–851. https://doi.org/10.6018/analesps.30.3.201241

Kim, M. K., & Park, J. (2024). Linking scientific concepts with students' personal daily lives: Using the metaphysical meaning of scientific concepts. *Journal of Baltic Science Education, 23*(5), 882–898. https://doi.org/10.33225/jbse/24.23.882

Lestari, D., Darmawijoyo, & Aisyah, N. (2018). Development of APOS theory-based student worksheets on plane solid geometry material in junior high school with the context of Musi Banyuasin traditional houses. *Kreano: Jurnal Matematika Kreatif-Inovatif, 9*(1), 1–9. https://doi.org/10.15294/kreano.v9i1.11946

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. National Council of Teachers of Mathematics.

Nurhayati, A., Sari, B. D., & Putri, C. L. (2022). The effect of small group interactions on students' critical thinking and mathematical problem-solving skills. *Jurnal Pendidikan Matematika*, 10(1), 45–58. https://ejournal.unsri.ac.id/index.php/jpm

Pólya, G. (1973). *How to solve it: A new aspect of mathematical method* (2nd ed.). Princeton University Press.

Pratiwi, D. D. (2019). Development of linear algebra teaching materials based on Islamic values using a scientific approach. *Desimal: Jurnal Matematika, 2*(2), 155–163. https://doi.org/10.24042/djm.v2i2.4200

Soleha, E., & Ihsanudin. (2024). Pengaruh pembelajaran kolaboratif terintegrasi *Computer Supported Collaborative Learning* terhadap kemampuan komunikasi matematis siswa SMP [The effect of collaborative learning integrated with Computer Supported Collaborative Learning on junior high school students' mathematical communication skills]. *Jurnal Pendidikan MIPA, 14*(2), 723–731. https://doi.org/10.37630/jpm.v14i2.1540 (E-Journal STKIP Taman Siswa Bima)

Tambunan, L. O. (2021). Meningkatkan kemampuan pemecahan masalah dan komunikasi matematis dengan strategi kooperatif tipe *Student Teams Achievement Divisions* [Improving mathematical problem-solving and communication skills using the Student Teams Achievement Divisions cooperative strategy]. *Jurnal Pendidikan Matematika Raflesia, 6*(1), 108–119. https://doi.org/10.33369/jpmr.v6i1.12156

Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D* [Quantitative, qualitative, and R&D research methods]. Alfabeta.